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and The COMPOSITE CATALOG
for the drilling-producing-pipe line industry

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Don't pass up the opportunity to avail yourself of the wealth of process information coming in September in the 1948 PROCESS HANDBOOK. For details, see page 163.

PETROLEUM REFINER

Specialized for the process division of the oil industry—refining, cycling, natural gasoline and petrochemical operations.

R. L. DUDLEY, President, Publisher A. L. BURNS, General Manager

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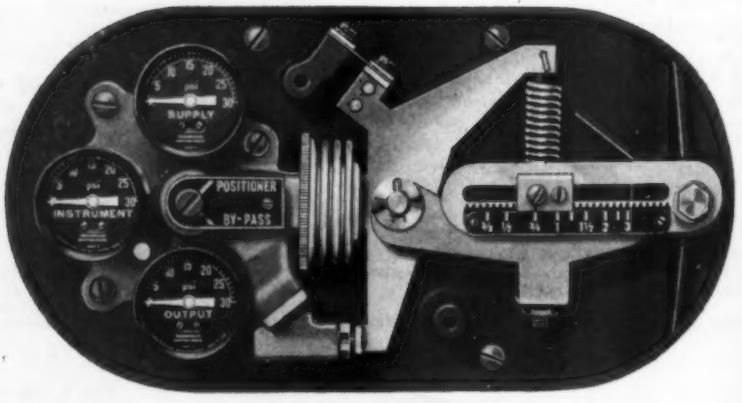

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VOLUME 27, NO. 7 JULY, 1948

PETROLEUM
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SPECIALIZED FOR THE PROCESS DIVISION OF THE OIL INDUSTRY — REFINING, CYCLING, NATURAL GASOLINE AND PETROCHEMICAL OPERATIONS

A GULF PUBLISHING COMPANY PUBLICATION

THE LOOK BOX

ANOTHER important use for petroleum may result from the development of a completely synthetic varnish, said to be the first such product. Certainly the use of petroleum here would do much to ease the worldwide shortage of edible fats and oils. The varnishes were announced by H. Dannenberg, T. F. Bradley, and T. W. Evans of Shell Development Company, Emoryville, California, in a discussion at a recent ACS meeting in Chicago.

Petroleum Fills Another Niche

Up to now, the so called synthetic paints and varnishes have employed such natural products as linseed oil, soybean oil, and cottonseed oil as major ingredients. Since some of these natural oils have food value, their continued use in non-food applications constitutes a drain on the worlds food supply.

The new varnishes require no other raw material than petroleum, according to the report, which explained that they are prepared from a new petroleum chemical, glycerol allyl ether. The products are said to be especially effective as industrial finishes on metal, and as furniture lacquers, forming insoluble films of high mechanical and chemical resistance.

Glycerol allyl ether, the chemical used in the new varnishes, is a water-white liquid which is made from propylene gas in a series of chemical process steps. Propylene is abundantly available from petroleum. Glycerol allyl ether, alone, is not a surface coating material. For this purpose it is reacted with certain acids, such as those used in the manufacture of alkyd-type resins. These also are in general obtainable from petroleum, as, for instance, phthalic anhydride from petroleum xylene. Quoting the authors, "While the synthesis of glycerol allyl ether requires highly specialized equipment, the reaction with the acid is a simple process and can be carried out readily by the varnish manufacturer who has modern processing equipment at his disposal. A variety of products can be prepared this way, depending on the acid chosen. The varnishes obtained are particularly useful for applications which now employ resins made from a combination of synthetic materials and scarce natural drying oils."

INCREASES predicted by forecasters for our present tremendous petroleum consumption seem to be running on or ahead of schedule. Engineers who met at French Lick, Indiana, for the Summer Meeting of the Society of Automotive Engineers were told by J. W. Barriger, president of the Chicago, Indianapolis, and Louisville Railway Company, that diesels already surpass steam locomotives in virtually all respects and that rapid future progress in design and development will establish the diesel as definitely superior. He predicted that American railroads will be largely dieselized by 1955.

Economies Follow Dieselization

While the diesel locomotive is the most expensive motive power unit, Barriger said, it can make even continuous continental runs with ease and dependability, and be ready for the return journey with only routine servicing. "Every four years the railroads spend the equivalent of their original investment in steam locomotives in repairs to them. The gross annual expenses of owning and operating steam locomotives represent about

. . . growing in popularity

BEAIRD

RETURN BEND

FITTINGS

SINCE 1918
BEAIRD
SHREVEPORT

30th Anniversary

SHREVEPORT, LOUISIANA

75 percent of the original cost of these machines. It is obvious from such basic considerations that an important capital investment is justified to obtain the economies that follow dieselization."

Cars For Human Beings

HONESTY and grace in automobile body design should contribute character in motor vehicle styling, Wilder Hobson, of *Fortune* Magazine, New York, advised the Society of Automotive Engineers during the recent Summer Meeting at French Lick.

Hobson declared that a good car is insulted by any sort of stylistic fraud or ostentation, such as metal discs to imitate white sidewall tires, metal station wagon bodies painted to imitate wood, and large hoods over small engines,

"It would appear," he commented, "that a great deal of American body styling has taken a brash leap into the future. Not, to be sure, into any future which might be considered imminent, but into that perpetually lurid and seething future which is presented to the eyes of young persons ir the scientific comic strips. What used to be the horseless carriage has become a sort of spaceless moon rocket, a glossy, torpedo-like contraption—a pretty swollen torpedo—which seems to chafe at the humble roadwork it is called upon to perform and strains to be off into the interstellar space so popular with bug-eyed readers. Frankly, I am always somewhat surprised to discover ordinary human beings in these cars."

Imperilling the American System

IN A recent address before the Commercial Chemical Development Association, Henry C. Breck, vice president, Union Securities Corporation, observed, "There is a gradual disappearance during the past several years of the defeatist attitude toward industrial growth and capital expansion in the United States, which had its origin, perhaps, in the severe depression in the early 1930's, but which was nurtured by a political philosophy claiming that the business frontiers of America had been passed. Even had no great war come, with its imperious demand for more of everything and for many new products, it is probable that we should have regained the traditional American belief that free enterprise, private profit, and hard work are more likely to bring us national happiness than sitting in government legislated security to watch different colored, but mostly pink, rabbits pulled out of a White House hat. It would be uncomplimentary to the American genius for common sense to assume otherwise."

Attention was directed to the decline of available capital, so vital to American industry. Large users of new capital are being forced to borrow.

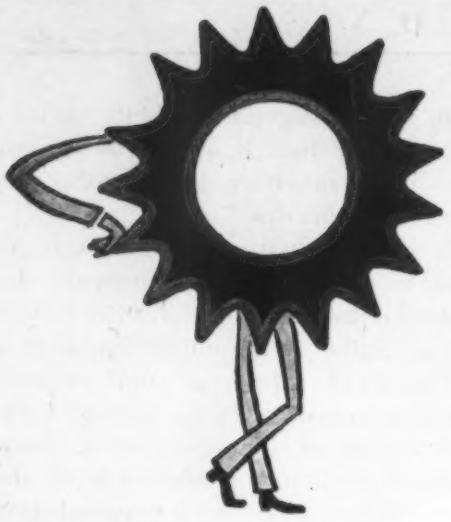
"I need not elaborate the unhealthiness of such a trend. I suspect that the trend could be reversed if our present system of taxes, particularly personal income taxes, were substantially altered. The present high costs of living, combined with almost confiscatory taxes imposed upon personal incomes in excess of $12,000, have practically eliminated the active business man as a purchaser of new securities. The same causes have eliminated those who had retired or who had inherited wealth.

"Seldom have we seen a better illustration of the dictum of our great first Chief Justice that 'the power to tax is the power to destroy.' Whatever justification there may have been for such heavy wartime taxes to insure the survival of our country has now largely disappeared. Unless they are reduced promptly and substantially, we may find that we are imperilling the survival of our system of free enterprise; for no business which is forced either to borrow excessively to obtain new money, or to take such new funds from some government agency, as in the totalitarian state, can long remain free."

"Fido" Now In California

FIDO, the wartime fog dispersal system developed in this country and used extensively with great success at military airports in England to raise fogs from "ceiling-zero" to as much as 800 feet visibility, has been incorporated in the first major commercial application at the Los Angeles airport.

Action of the dispersal system is almost instantaneous. A charge of highly volatile and combustible petroleum liquid is ignited in a flash flame effect. Pumps serving the system are reported to handle 1100 gpm of fuel at a pressure of 1200 psig. This would seem to be a rather large fuel load, although the actual quantity of fuel used per fog is not stated. Since the equipment will be in operation only when needed perhaps the fuel requirements will not be too serious. Other installations are expected to follow in all of the larger cities. Quite obviously, anything that will promote the safety of air transportation deserves high priority in our schedules for the utilization of petroleum products.



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Psychology Of Safety

F. J. SLUZE, Safety Director
Ashland Oil & Refining Company, Ashland, Kentucky

ABOUT 25 or 30 years ago psychology broke loose from its confinement in classrooms and the seclusion of bearded professors and exploded on the general public and industry with a bang.

Some of us hard-boiled industrial supervisors hearing the magic word for the first time thought that at last a science had been worked out that would give us an easy way to understand and cope with the variables of human behavior.

The more progressive supervisors went out and bought books dealing with the subject and studied them passionately in the hope that this new slant on human nature would end their supervisory headaches.

Naturally we dug up a definition for this newly acclaimed science and very carefully memorized it as follows: *Psychology is the science of the activity of the individual in relation to his environment.*

We pondered over personality, motivation, emotional and effective responses, learning, nature of man, and many other subdivisions of this magic science.

Our next step was to go out and apply this newly acquired learning. Imagine our disappointment when we tried our new ideas on some hard-boiled foreman. How could we persuade him that there was a scientific way to handle the men in his charge? How could we teach an old dog (which includes supervisors and workers) new tricks?

What made a fellow say, "I've done it this way for 20 years and can't see any reason for changing now"?

What is it that makes one fellow say, "That foreman of ours is tops" or again "Our foreman is a dirty rat."?

The answers to these questions naturally take us into the field of applied and practical psychology.

But to get back to the psychology of safety, not more than 10 percent of the work done by safety engineers deals with direct engineering work as most professional engineers understand it. The other 90 percent involves dealing with and the proper handling of people.

Practically all plants have within them the latent ability to reduce accidents to a minimum if that ability is used. The successful safety engineer *must make sure* that it is used. His work is concerned with men and women, their likes and dislikes, temperaments, peculiarities, their weaknesses and strong points, and their wishes and resentments.

A plant is safe only when all hands are safety minded; and by that is meant top management in the plant or company, staff officers, line officers, and the individual workers. They must bring to bear a combined safety consciousness on every part of the work being done.

A thoroughly qualified safety engineer, director, or supervisor must not only be informed in many fields, but he must also develop and advance as an individual personality, with a profound curiosity, a measured tolerance, and a sympathetic outlook combined with the conscientiousness of the perfectionist.

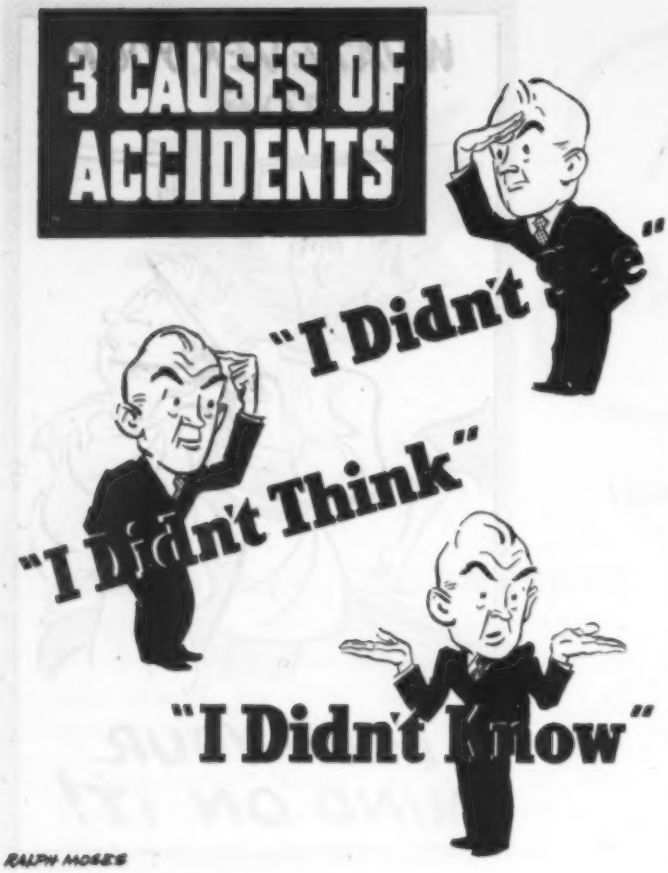
Let's review a case in point I experienced many years ago. The concern I worked for at that time had 13 fatalities and 11 serious injuries from gas ignition in one year alone. My diagnosis indicated a change in the type of lighting if this slaughter were to be eliminated. I went to the general manager and proceeded to apply my newly acquired knowl-

THE author's article "Safety Is No Accident at the Ashland Plant," presented in the January, 1948, issue of *Petroleum Refiner*, was accorded a hearty response by our readers; so his suggestion for two more articles, "The Psychology of Safety" and "Engineering for Safety" was a welcome one.

In the first of these two discussions, Mr. Sluze gets down to bed-rock in ascertaining and following through on this "psychology" thing.

There's nothing particularly profound in what he sets forth. Anybody's safety committee worker can understand every word he has written. In fact, that's one of the big reasons why it is given space. Another, of course, is that the topic of safety deserves attention in the industry at all times.

Illustrations, including the effective poster-cartoons are from the National Safety Council, Chicago.



edge of psychology. I proceeded with the following approaches: "If we don't control these accidents, the public will brand our company a slaughter house and refuse to apply for work here." His reply was, "I am not concerned about the public's attitude. There is a surplus of manpower in this area anyway, so don't worry about people staying away." Not much sentiment in that response, was there?

I tried another line of attack. I advised him that the morale of our personnel would nosedive to a very low ebb. His reply, "Morale is that intangible something that is buoyed up by the rate of pay, and we pay the highest wages in this area." Not much emotion to that response either, was there?

Undaunted, I approached the problem by appealing to his sentimental instincts by describing the widow and several children left without their breadwinner. Not much success with this approach either because his reply was, "The deceased knew he was working in a hazardous industry when he came here, and besides we insure all of our employes, and again there are the compensation payments.

In desperation I tried one more approach. The cost of the new equipment I was recommending was $90,000; so I pointed out that the 13 fatalities for that year alone from this source would total $65,000 not to mention the cost of the serious injuries. This struck a responsive chord, for I could see him doing some mental arithmetic which no doubt convinced him that in less than two years the equipment would pay for itself. And lest we forget the elimination of fatalities from that source was achieved and the saving was realized.

So much for top management. How about line officers? I remember a number of years ago when the successful foreman was the one who could fluently alibi his way out of responsibility for an accident by such stock explanations as: "He was one of the most reckless men in my charge." "I told him to be careful," (which conveyed no concrete information to the worker whatsoever.) "He always did what I told him—he was one of my safest men." This same foreman lost three of his safest men in one year. Or "I just left him a few minutes before the accident." (Here he was trying to imply attention to duty.)

Or how about the old stock answers on the injury reports where the question asked was "What was the cause of the accident?", and the answers were invariably — carelessness, recklessness, thoughtlessness, or ignorance on the part of the injured. Were these failings the fault of the worker or his foreman?

Or let's take the worker's old attitude. Some of it still remains. Sparring, tripping, hot footing the other guy, upsetting chairs or benches and dumping the occupant on the floor, not to forget compressed air pranks, are included. I recall endeavoring to get the workers to wear protective hats and their resentment to change with the following stock answers: "They make my head ache." "I am losing hair on account of the hat." "They cause irritation of my forehead." "The hats are too heavy." "All this protective equipment makes me look like a sissy." "I've been on this job for ten years without a hard hat and nothing happened yet."

How was psychology put to work for safety? There were many channels such as education of workers and supervisors for safety; publicity in the form of bulletins, safety meetings, and safety manuals, safety literature; stimulating competition through inter-plant and inter-company contests; competitive score boards; appointment of workers to inspection committees; individual and collective reward for accident prevention achievement; encouraging suggestions from workers by means of suggestion systems; first aid training; sound slides and motion pictures; orientation of new employes.

Conveniences In Conference

I recall a technique we employed to get the supervisor to assume responsibility for the safety of his workers. This project called for a series of conferences to drive home the foreman's qualifications, duties, and responsibilities. The groups consisted of men engaged as foremen. We planned to hold these meetings evenings in the schoool buildings, but several obstacles crept up. In foreman conference training the atmosphere must be informal, not too large a group for each leader, and a clean, well lighted and well ventilated place for the meeting. Lastly smoking and chewing should be allowed if the members are to be put at ease. Children's school rooms were not any too satisfactory, as many would agree if they tried to squeeze themselves into desk seats intended for ten-year olds. Smoking was a definite obstacle due to state laws that forbid it in school buildings.

Well, this didn't discourage us because we decided that the question of smoking could be taken care of by moving into the boiler room. Here we set up a long conference table with chairs and placed spittoons handy for the tobacco chewers—ash trays for cigarette smokers, and coal pails for pipe smokers. This was not the most attractive conference room, but it certainly had the conveniences, and you can rest assured that the conferees were at ease.

To bring our supervisors to a realization of their

responsibilities toward safety of their employes we started out by discussing the difference between blame and responsibility for an accident. Many definitions were given, but the group finally agreed that blame for an accident usually fell upon the injured, a fellow worker, or the immediate supervisor while responsibility started at top management and flowed down through the different levels of supervision from the general manager and higher down to the supervisior in direct charge. No one could shed his share of responsibility, they agreed.

Active discussion by foremen affected and group accord on the decision brought home the understanding and realization of responsibility very vividly.

Safety meetings, a psychological approach to safety consciousness, evolved from "mass meetings" that used some supervisory bigwig who talked safety till he was blue in the face, criticizing, fault finding, and nagging, while the apathetic worker stole a few winks or gazed out the window if such an opportunity presented itself or squirmed and cussed under his breath because he was going to be late for supper that evening. (These "mass meetings" in many cases were held after quitting time on the workers' time.) As time went on, progressive concerns awoke to the fact that active participation by workers brings a positive response so they turned to the conference method with its problem solving discussions.

Since the major percentage of accidents was due to man failure, a study of the psychological causes of recent accidents rather than property or equipment defects became the vogue of alert safety men. Often the injured was invited to describe the accident to his fellow workers (which in itself drove home the faulty moves he made and impressed indelibly on his mind the safe way to do the job). Safety courts were used employing a mock trial technique with attorneys for the accused foreman and plaintiff and the final placing of responsibility. This aroused the foreman to his sense of responsibility. Reviewing recent injury reports proved to be a very good medium for bringing out the unsafe act also.

Bulletins intended to appeal to the finer instincts of the worker ran the gauntlet from simple slogans such as "Safety first—safety always," "A careful man is a safe worker"; then rhymes and jingles like: "When you hear the quitting bell, don't start running fast as hell, you may trip or you may fall, and you may not get home at all"; catch phrases such as "Work Safely, Death is so permanent"; gruesome illustrations such as a bleeding arm stump or mangled hand, and lately a touch of humor in the form of cartoons. All these were intended to play on human emotions that would bring about a receptive response and in that way arouse mass safety consciousness.

Safety rule books and manuals passed through a process of evolution beginning with early ones that laid emphasis on "dont's" creating a negative impression. How many of us remember: "Don't oil machinery while in motion," "Don't run when you hear the quitting whistle," "Don't stand under a suspended load," Don't take chances," or "Don't lift improperly." These don'ts were wrong according to the laws of psychology because a negative response was created and would have to be erased and the correct impression substituted for it.

A little later some safety engineers conceived the idea that a book of rules or regulations could be compiled by procuring a number of such books already compiled and used by similar plants or industries and then consolidate the most appealing rules into a new manual and then issue this new masterpiece to the personnel on a "take it or leave it" basis. This method enhanced the safety engineer's reputation as a skillful and clever fellow but did very little to advance the safety consciousness of the workers. They reacted much like our forefathers except instead of taxation without representation, it

FROM ME TO YOU, LOVER-BOY!
Work more safely, Won't you, Jack? I Just Don't look So good in black!
DON'T YOU FOLKS HAVE A SAFETY PROGRAM OVER HERE? I'VE NEVER SEEN SO MANY GUYS WITH THEIR HEADS BANDAGED!

became regulation without representation will not be tolerated.

The next and most logical step was to permit representation on any code of rules or set of safety regulations. So wise safety authorities took their accident prevention problems to the workers and supervisors and obtained their reactions and first hand opinions on practicability, facility, and economic advisability. This method of legislation was bound to be successful and adhered to since those affected had a voice in the making of these rules—this was definitely regulation with representation.

Safety contests are utilized by many companies as a means toward promotion of group safety consciousness. Stacking one department against another, one plant against another, or one company against another as is done in National Safety Council contests introduces the competitive stimulus.

Competitive scoreboards showing the number of days operated by a given department without a lost time injury focuses attention on the importance of working safely especially if the score has accumulated to the point where it instills pride into each and every worker in such departments.

Appointing workers to plant inspection committees is an excellent medium for promoting safety consciousness since it gives the appointee a sense of importance as well as familiarizing him with the knack of spotting unsafe practices and unsafe conditions which he often carries over to his own work.

Reward for accident prevention achievement gives workers an incentive to perform their job safely. Although it seems silly to pay people to keep themselves from getting injured nevertheless many safety authorities will go on record as endorsing this form of stimulus.

I remember a case where one company offered to give each worker a ham to take home to his family if his department worked a certain length of time without having a lost time injury. Unfortunately one of the men suffered an injury and spoiled the record and knocked everyone out of a free ham. The rest of the men were so incensed they were willing to tar and feather the unfortunate fellow. This form of stimulus has two disadvantages —the terrific letdown after the record has been stopped and the tendency to keep men on the job regardless of the extent of the injury in order to preserve the record. As one safety man put it—a man with a broken arm was wheeling another man with a broken leg around the plant—both supposed to be back at their regular jobs.

Safety suggestion systems utilize creative thinking which is an active form of safety mindedness. If rewards are given, they add the profit or monetary incentive. Even when rewards are not given but acknowledgement is given for good suggestions, it appeals to the contributors' sense of pride. Where suggestions are made verbally to the foreman, it is the duty of the foreman to acknowledge the originator of the suggestion; otherwise the worker will call the foreman a so-and-so glory grabber while talking to fellow workers and vow that he will see the boss in hell before he makes another suggestion.

If a suggestion has been made by a worker to a foreman and accepted and completed, the foreman should inform the worker of the fact.

If the suggestion is a little far fetched, uneconomical or not applicable, the foreman should tactfully tell the worker so.

If the suggestion has been tabled or pending, the foreman should likewise inform the worker.

One of the weaknesses of this plan is the tendency on the part of the workers to suggest correction of equipment or conditions solely and offer nothing to correct unsafe practices because they think that reporting unsafe practices smacks of squealing.

A wise safety man (not the foreman this time) will accept suggestions in confidence and not report the source of his information except where it will react to the benefit of the suggestor.

One of the most effective stimuli toward accident prevention is wholesale first aid training. It has been discovered that a trained first aid man automatically becomes a safer worker since dressing and reviewing the different injuries that can occur in industry makes a lasting impression on the trainee's mind, and he subconsciously builds up a defense against such injuries. Applying the lessons learned in first aid on the job also promotes good fellowship among workers because the care and attention given to an injured man by a fellow worker is the finest expression of cooperation, and we can readily understand the gratitude and friendship of the injured man.

Sound slides and motion pictures have been used to good advantage.

Where the nature of the job is such as permits daily inspection by the safety engineer, it is to the advantage of the safety engineer to make such inspections. In addition to accumulating discrepancies for future followups, the inspections add to the workers' sense of security. Workers on a hazardous job develop confidence when they see the safety engineer staying on the job during the critical period.

Accident investigation committees have been an excellent medium for promoting safety consciousness

among supervisors especially. The foreman in charge being cross-examined, it made lasting impressions on his mind. The members of the investigating committee also benefited from their experience, and workers questioned as witnesses took with them certain lessons gained during the investigation.

Another plan used was to organize an investigation committee consisting of two superintendents recruited from two plants other than the one where the serious or fatal accident occurred. We visited the scene of the accident, interrogated the foreman in immediate charge and any witnesses to the accident. We then retired to the plant office and discussed the case in order to determine the cause or causes of the accident and measures to be taken to prevent a recurrence of that kind of accident. If all three were in accord, we all signed the joint report. If there were a difference of opinion, then a majority and minority report were drawn up and submitted to management. Not only did such investigations provide corrective measures but all who participated in the investigation derived some psychological benefit from the investigation. Superintendents on such investigations also took time out to observe conditions and practices at the other fellow's plant and often took with them some very good ideas for their own plants.

"Fire Marshal" Inspections

A rather unusual scheme is used with my present employer and associated refiners. We call ourselves the Kentucky, Ohio, and West Virginia Refinery Fire Marshals. At intervals of about three months we band together and inspect each other's refineries. We employ a rating system and divide into competitive teams. At the end of the inspection we meet and review the findings of each team and then declare the winner who found discrepancies that totaled up to the greatest number of points. The reviewing of discrepancies is done in the presence of the management, and they may accept or reject any suggestions made. Here again the visitors keep their eyes open for new ideas and innovations. You can readily see the psychological effect of such inspections on management and workers.

One may not be in complete accord with all that has been advanced here; for example, the statement that 90 percent of the safety engineer's work involves *dealing with and the proper handling of people.* Or putting it another way, 90 percent of preventable industrial accidents can be attributed to man failure while 10 percent can be attributed to unsafe conditions or equipment. Or you may have put psychology to work for safety in other ways than: education, publicity, contests, scoreboards, achievement awards, inspection committees, suggestion systems, first aid training, foreman conference training, safety meetings, safety manuals, safety literature, safety engineers' inspections, accident investigating committees, refinery fire marshals' inspections, sound slides and motion pictures, and orientation of new workers. If you have, we would be glad to hear from you.

There is agreement, however, that the following can be effectively appealed to through an organized promotional safety program:

1) Instinct of self preservation.
2) Desire for material gain.
3) Desire for praise, approbation, or distinction.
4) Fear of ridicule or disapproval.
5) Sense of humanity.
6) Sense of responsibility.
7) Sense of loyalty.
8) Competitive instinct.
9) Desire for power or leadership.

We also agree that a great deal of progress has been made in the guarding of machine and physical or material hazards, and—

That true psychology should be considered in deciding upon remedies that will supplement those selected as a result of cause analysis, and—

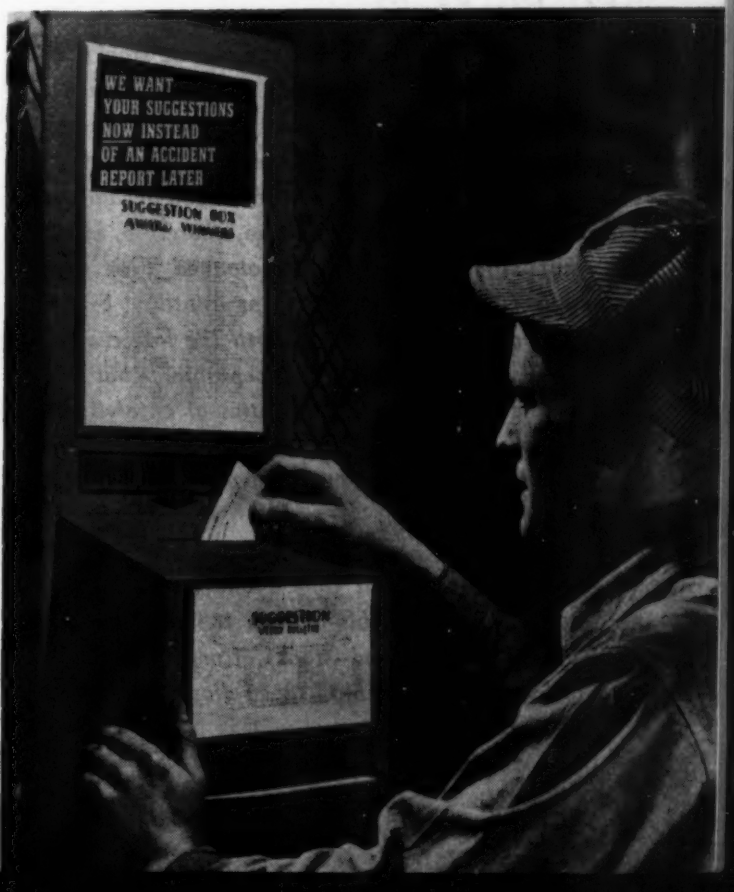
That there is a wide open field of usefulness in applied safety psychology and it should receive more immediate and widespread application.

Therefore, it is contended that industrial safety work properly organized, consistently maintained utilizing applied psychology in addition to the older approaches inculcates a superior attitude of mind toward accidents.

The establishment of this superior attitude governing the conduct of management and workers will result in real accident prevention, and it will do this without interfering with production but on the contrary it will reduce production costs which should justify itself on the basis of economic grounds.

So everyone—foremen, managers, personnel directors, safety engineers, and all others—should resolve to utilize all the techniques old and new in bringing about the maximum of accident prevention and be rewarded in the manner expressed by P. B. Juhnke who says, "The end will be that the workman shall live to enjoy the fruits of his labor; that his mother shall have the comfort of his arm in her age; that his wife shall not be untimely a widow; that his children shall have a father; and that cripples and helpless wrecks who were once strong men shall no longer be a by-product of industry."

Such wholesome reward merits the enthusiastic acceptance of one's full obligation toward accident prevention.



DIESEL FUELS from *Catalytic Cracking Operations*

T. L. APJOHN and F. L. NELSON
Socony-Vacuum Oil Company, Inc., Laboratories,
Research and Development Department, Paulsboro, N. J.

***STRAIGHT** run distillate fuel oil fractions, which constitute the major portion of the fuel that has been used in high speed diesel engine equipment since its inception, are becoming more scarce in the face of an increasing demand for compression-ignition engine application. Primary reasons are 1) the influence of growing domestic heating oil requirement; and 2) factors concerned with petroleum refining operations, particularly catalytic cracking, for the production of more and higher quality gasoline. Straight run distillates are desirable as catalytic cracking charge stock because of the high yields of gasoline and their contribution to high operating efficiences of the units themselves as compared to cracked or heavier straight-run charge stocks.*

Conversion of straight-run stocks in catalytic cracking units has, of course, resulted in the production of distillate stocks within the volatility limits of diesel fuels. These have been designated as "cracked" stocks and have, therefore, somewhat unjustifiably been catalogued with thermally cracked stocks of similar volatility. Experience in high speed diesels with the latter materials has not been entirely acceptable. What then are the operating characteristics of catalytically cracked diesel fuels and how do they differ from their thermally cracked and straight run counterparts?

A complete answer to this question cannot be made at the present time. However, what information has been obtained on the utilization of catalytically cracked stocks, from Houdry and TCC operations, in high speed diesel engines has been reassuring.

THE diesel engine builder and operator have heard repeatedly since the end of the war that, for most economical operation, the diesel engine should be capable of operating on catalytically cracked fuel oils. The reasons behind this statement have not been too extensively expounded nor has there been too much information available on what to expect in the way of quality characteristics in such catalytically cracked stocks.

The reasons for curtailed availablility of straight run fractions for diesel use and the increased proportions of catalytically cracked stocks are related to supply and demand considerations of all petroleum products both quantitywise and qualitywise, and are also related to the economics of refining and product distribution.

Crude oil production and crude runs to refining equipment are currently at an all time high level. Figure 1 charts this increase in crude petroleum processing over the past 15 years and indicates predicted requirements during the next four years. These are up markedly from those estimates made a year ago and seem thoroughly justified on the basis of today's domestic demand, its probable growth, and exports planned to aid in European recovery.

Influence of World War II

Figure 2 indicates relative domestic consumption of the principal classifications of petroleum products since the early part of this century. Increased gasoline yields at the expense of fuel oil was initiated in earnest with the advent of thermal cracking immediately after World War I and continued until the early 30's. Relative yields of the principal classes then remained substantially unchanged until World War II demands were felt. At this time there was a reversal in trend brought about by demands for fuel oil in industrial and marine and naval equipment.

A significant point is that the relative demand of fuel oils has continued to increase since the war and consumption estimates projected through 1952

MILLIONS OF BARRELS PER DAY

July

indicate a continuation of this trend. Figure 3, relative distribution of fuel oil by type of stock, shows that demands for distillate fuel, including diesel fuel, are responsible for this most recent increase in the ratio of fuel oil to gasoline. The increased requirement for distillate is, of course, accountable chiefly to the conversion from coal to oil in domestic heating which was just gathering momentum at the outbreak of the war. Since the war, householders have tried to, and nearly have, made up for the reversal imposed by war time demands, and this rush to conversion has contributed to the present dislocation between product demand and availability. Oil burner sales in 1947 were nearly three times those in 1941. On the basis of the past good record of the petroleum industry, it is generally felt that the public will continue to rate oil highly as a source of heat in spite of the present supply difficulties, and requirements for distillate will continue to increase. To meet these demands the industry must make large capital investments and exercise all of its ingenuity to find the necessary crude oil and to install the required processing facilities.

The Kerosine Situation

Percentagewise, kerosine consumption has remained substantially constant over the past 15 years. To meet burning quality requirements kerosine must be a straight-run product and may be obtained only from the more paraffinic crude oils unless rather extensive and expensive treating, such as solvent extraction is practiced. Availability is therefore limited. During the past winter this product was most critical of all from the supply standpoint and this situation threatens to exist next year. Its quality characteristics appear to be essential for satisfactory operation of many vaporizing type domestic heating systems, for range oil burners, and for certain diesel engine equipment, particularly that used in intracity bus operation.

It is apparent from a study of Figures 2 and 3 that increased yields of distillate and diesel fuels are coming largely at the expense of residual stocks. This is the natural course considering that, to the refiner, residuum is the end of the barrel and brings to him the least return. From the utilization standpoint, heavy fuel is most readily replaced in many of its applications by coal and natural gas without seriously upsetting the operations involved. To shift yield in the direction of distillates and away from residual stocks, a cracking procedure must be employed; thus, the incremental distillate fuel oils will be "cracked." This constitutes one force in the direction of more cracked components in fuel oil. There is, and has been, another force, the demand for higher octance number gasolines.

Thermal cracking began to be widely practiced in the early 20's when production line operations brought the automobile economically within the reach of the general public and gasoline requirements began to outstrip natural availability in crude oil. Fortuitously thermal cracking produced a gasoline with better ignition—octane number—characteristics than that occurring naturally in crude petroleum. It was more than a decade, however, before the automotive and petroleum industries caught up with the significance of octane number and the petroleum industry sought new ways to obtain higher octance number gasoline stocks. A product of this search was catalytic cracking which had a marked effect upon yield and quality of both gasoline and distillate fuels.

Relation of Gasoline and Fuel Oil

Figure 4 shows the relative yields of gasoline and fuel oil as volume percent of crude processed with increasing Research (F-1) octane number of the gaso-

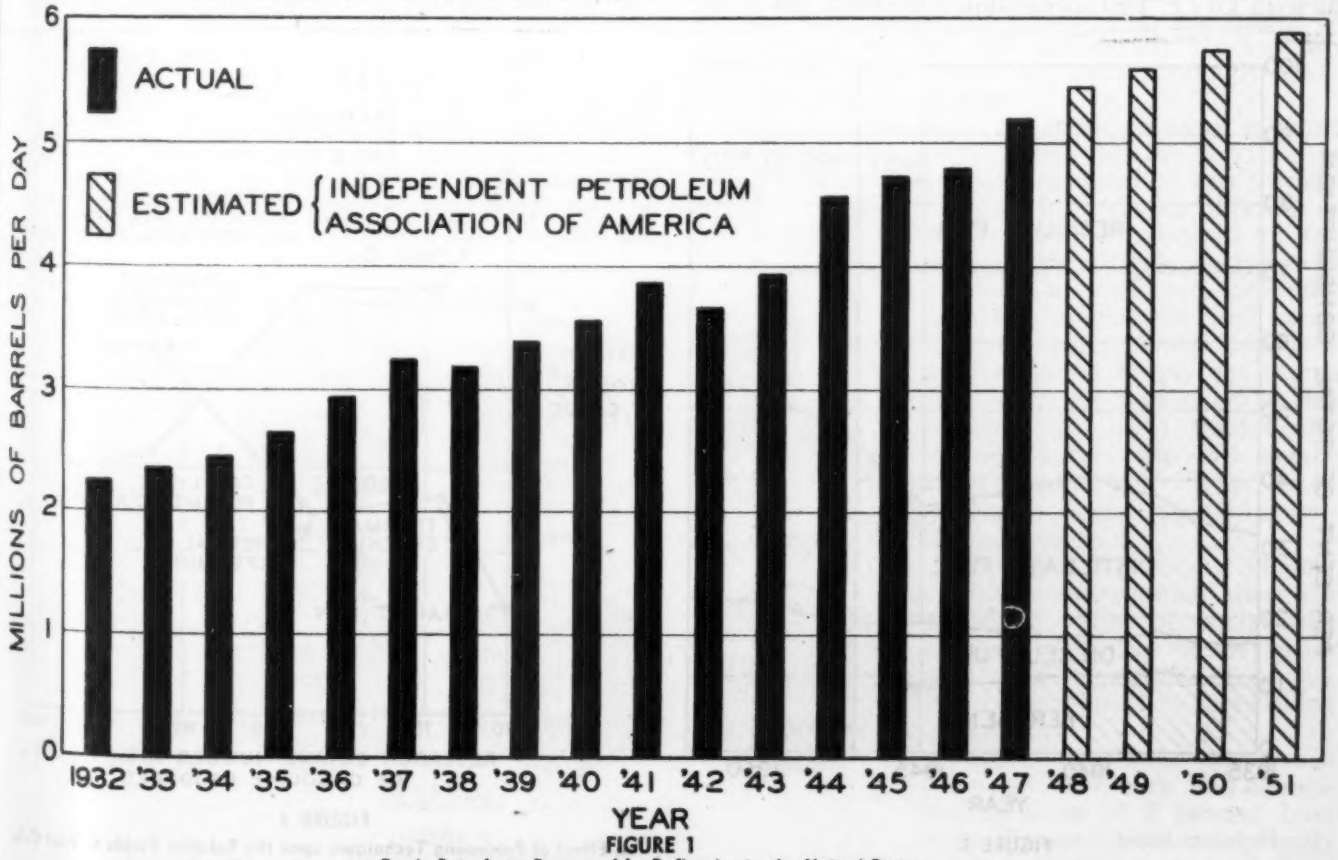


FIGURE 1
Crude Petroleum Processed by Refineries in the United States

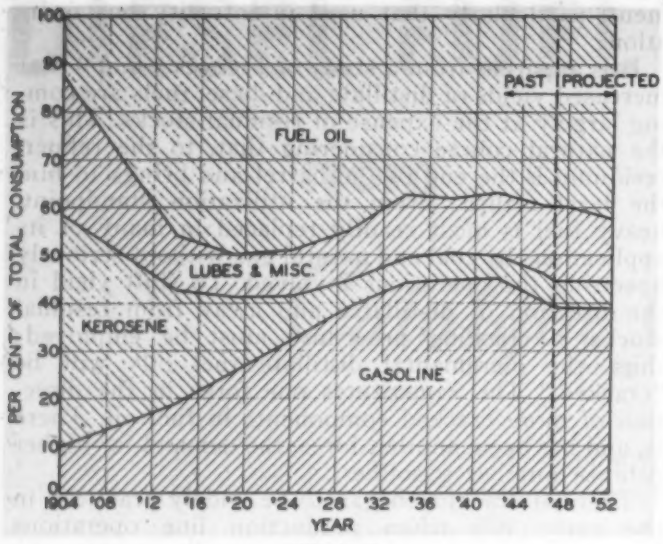


FIGURE 2

Relative Consumption of Principal Petroleum Products

line produced when using various processing techniques. Gasoline yield from simple distillation of crude averages about 23 percent and rates approximately 70 Research octane number with 1.0 c.c. tertraethyl lead (TEL) per gallon. Fuel oil yield, which includes both distillate and residuum, is about 76 percent, the balance is gas. With thermal cracking, the average yield of gasoline increases from 23 to 37 percent and a Research octane number of about 74 with 1.0 c.c. TEL per gallon is reached. Fuel oil yield drops to 62 percent if all thermal cracking is replaced by catalytic cracking, the fuel oil yield is reduced to 42 percent while gasoline yield is increased, with concurrent alkylation, to nearly 54 percent. The gasoline has a Research octane number of 92 with 1.0 c.c. TEL per gallon. Currently, the industry is well along the path of replacing thermal cracking with catalytic and, over-all, is capable of producing a gasoline of 85 to 86 octane number with 1.0 c.c. TEL per gallon. This provides for a potential fuel oil yield, including residuum, of approximately 55 percent. Out of the distillate portion must come such products as the lighter lubricating oil stocks, waxes, and many specialties.

Figure 5 gives an estimated distribution of stocks in both distillate and residual fuel oils from a prototype refinery during several periods over the last 40 years as new processing techniques for the production of gasoline were introduced. Prior to 1915 and the use of thermal cracking, all fuel oils were, of course, straight run. During the 30's when thermal cracking reached its peak, distillate fuels from a majority of the larger refineries contained about equal portions of straight run and cracked components. Residual fuels contained about 70 percent cracked material. The prewar introduction and wartime expansion of catalytic cracking facilities for the production of higher quality motor gasolines and aviation gasoline base stocks served to reduce further the straight run components in distillate fuels and replace thermally cracked stocks. Thus, the average refinery in 1947 produced a distillate containing about 40 percent catalytically cracked stocks; the remainder was about equally divided between straight run and thermally cracked distillates. Catalytic cracking produces no residual stocks since all materials incapable of being distilled from the catalyst are burned in the catalyst regeneration step. Consequently, the processing source of the residual fuels has not changed appreciably over the last 10 years. The estimated distribution of fuel oil stocks has been carried through the period 1950-1952. The continued trend toward expanded use of catalytic cracking is indicated.

From the gasoline production standpoint, straight

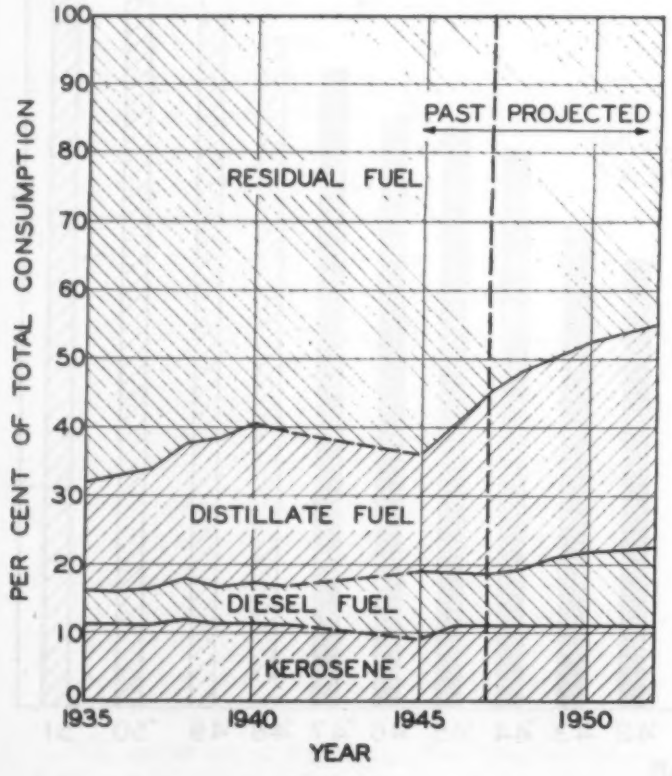


FIGURE 3

Distribution of Fuel Oil by Type of Stock

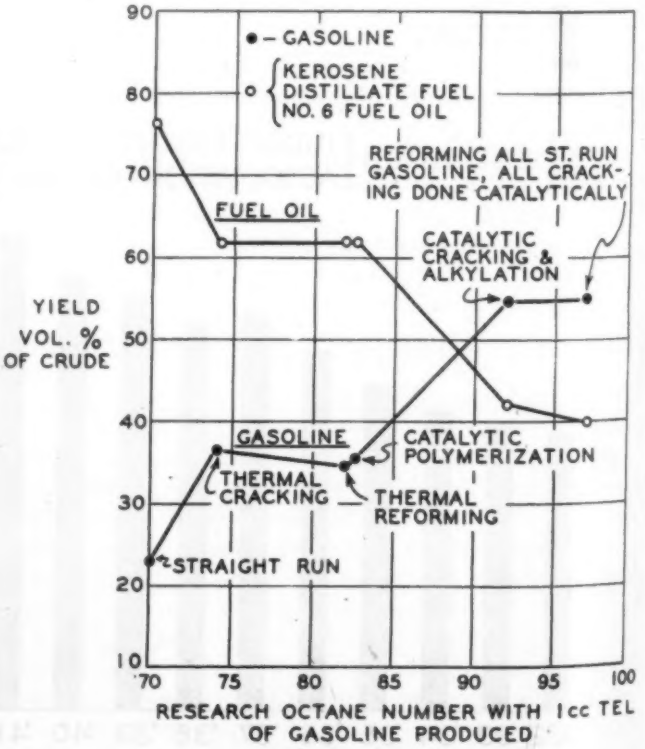


FIGURE 4

The Effect of Processing Techniques upon the Relative Yields of Fuel Oils and Gasolines from Crude Petroleum

run distillates provide the ideal charging stock to catalytic cracking units. Gasoline yields are larger than those obtained in charging either thermally cracked or catalytically cracked distillates. Residual materials, where charged to catalytic units, cut throug-put relative to distillates as a result of the extensive carbon formation on the catalyst and subsequent problems of catalyst regeneration and heat recovery.

In the prewar years, with straight-run distillates relatively plentiful and the demand for all products as well as high speed diesel fuel low, compared to productive capacity, ideal fuels have been made available to the diesel engine operator. Increased demands for distillates for catalytic cracking have been noted. Distillate use in domestic heating from 1941 to 1947 has nearly doubled. In addition, diesel applications are expanding significantly as shown in Figure 6 which charts past and projected demands for distillate diesel fuels according to end use. In the face of these demands and limited facilities to meet them, the refiner is losing the inducement to segregate his meager supply of straight-run fuels for a particular end use. There is in prospect, therefore, that catalytically cracked distillates will find their way more and more into diesel fuels.

As indicated in subsequent paragraphs, the utilization aspects should not be insurmountable and undoubtedly can be taken in stride by the aggressive diesel engine manufacturer with a modicum of effort toward making those engine design changes required for more suitable adaptation of a certain few fuel quality characteristics of catalytic stocks which differ from straight run.

Utilization of Catalytically Cracked Diesel Fuels

To identify the quality characteristics of fuels used in medium and high speed diesel engines, some or all of the following eleven requirements are generally specified:

Cetane number, ASTM distillation, viscosity, flash point, pour point, cloud point, ash, carbon residue on 10 percent bottoms, sulfur, corrosion, and finally, water and sediment.

Any discussion of ten of these requirements in connection with catalytically cracked fuels may be eliminated immediately by stating that through refining procedures normally used on fuel oils, most catalytically cracked distillates will meet all of them. The only exception arises in obtaining the high cetane number generally specified.

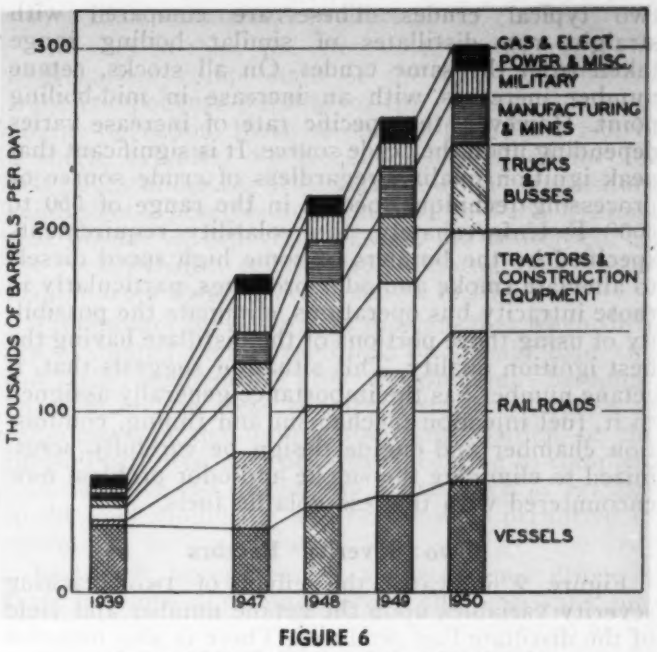


FIGURE 6
Past and Projected Consumption of Diesel Fuel

Cetane Number

Whereas most straight run distillates from paraffinic or mixed based crudes have cetane numbers in the range of 45 to 60, catalytically cracked stocks obtained from the processing of these crudes have cetane numbers 5 to 15 units lower. Straight run distillates in the diesel fuel boiling range from naphthenic crudes, on the other hand, may not exceed 35 to 40 cetane number and catalytically cracked distillates from these crudes are correspondingly lower in cetane number quality.

Using API gravity of the crude oil as an in index to its basic type, Figue 7 indicates the variation in cetane number of distillates obtained by catalytically cracking the virgin gas oil from crudes differing in API gravity. The approximate proportions of the basic crude petroleum types as produced are indicated. Generally speaking, intermediate and paraffin base crudes, which constitute approximately 75 percent of the total currently processed in this country, will yield catalytically cracked diesel fuels with cetane numbers of 40 or higher when processed under normal operating conditions.

There are, however, a number of other factors which affect the cetane number of catalytically cracked distillates beside crude source. Most significant among these are volatility and cracking severity.

Figure 8 charts the variation in cetane number with ASTM mid-boiling point of 5 percent fractions obtained from catalytically cracked distillates derived from

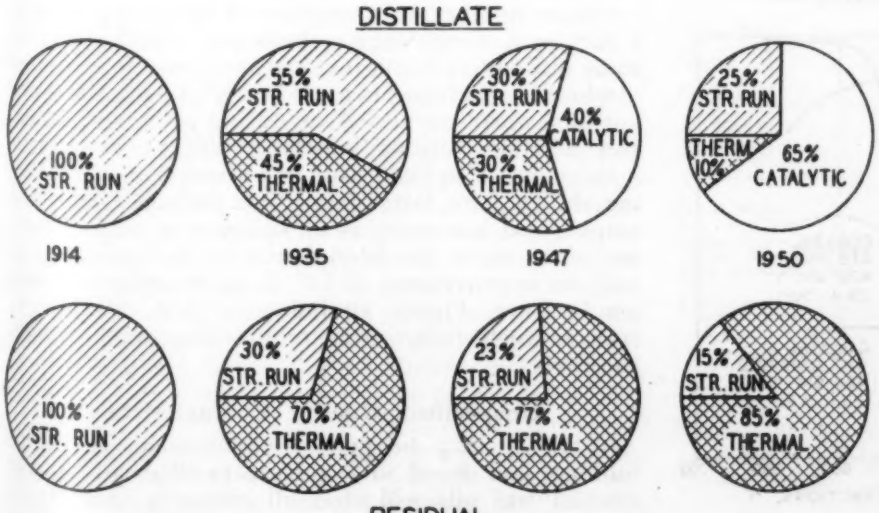


FIGURE 5
Estimated Distribution of Stocks in Fuel Oils for Prototype Refineries

two typical crudes. These are compared with straight run distillates of similar boiling range taken from the same crudes. On all stocks, cetane number increases with an increase in mid-boiling point. However, the specific rate of increase varies depending upon the crude source. It is significant that peak ignition quality, regardless of crude source or processing technique, occurs in the range of 550 to 600° F. Unfortunately, the volatility requirements specified by the builders of some high speed diesels to alleviate smoke and odor problems, particularly in those intracity bus operations, eliminate the possibility of using those portions of the distillate having the best ignition quality. This situation suggests that, if cetane number has the importance generally assigned to it, fuel injection mechanism and timing, combustion chamber and engine design be carefully scrutinized to eliminate the smoke and odor problem now encountered with the less volatile fuels.

Two Severity Factors

Figure 9 indicates the effect of two cracking severity variables upon the cetane number and yield of the distillate fuel produced. There is also included in Figure 9, relative yields and quality of the gasoline as a function of cracking severity. The two severity

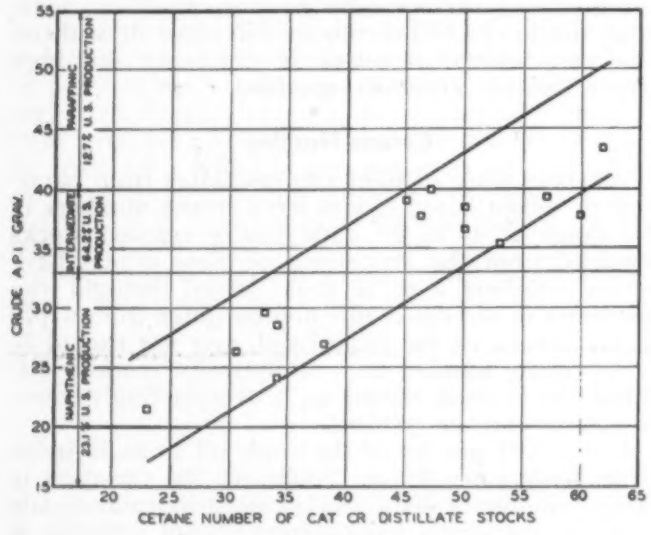

CRUDE API GRAV.
PARAFFINIC 18.7% U.S. PRODUCTION
INTERMEDIATE 64.2% U.S. PRODUCTION
NAPHTHENIC 23.1% U.S. PRODUCTION
CETANE NUMBER OF CAT CR DISTILLATE STOCKS

FIGURE 7

Crude Oil Gravity vs. Cetane Number of Catalytically Cracked Distillate Stocks. (Straight-Run Gasoil Charge to Cracking Unit)

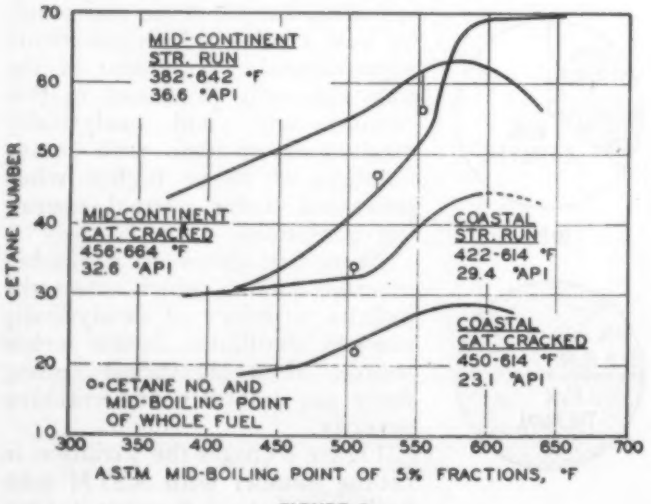

MID-CONTINENT STR. RUN 382-642 °F 36.6 °API
MID-CONTINENT CAT. CRACKED 456-664 °F 32.6 °API
COASTAL STR. RUN 422-614 °F 29.4 °API
COASTAL CAT. CRACKED 450-614 °F 23.1 °API
o-CETANE NO. AND MID-BOILING POINT OF WHOLE FUEL
CETANE NUMBER
A.S.T.M. MID-BOILING POINT OF 5% FRACTIONS, °F

FIGURE 8

Cetane Number vs. ASTM Mid-Boiling Point of 5 Percent Cuts from Distillate Fuels

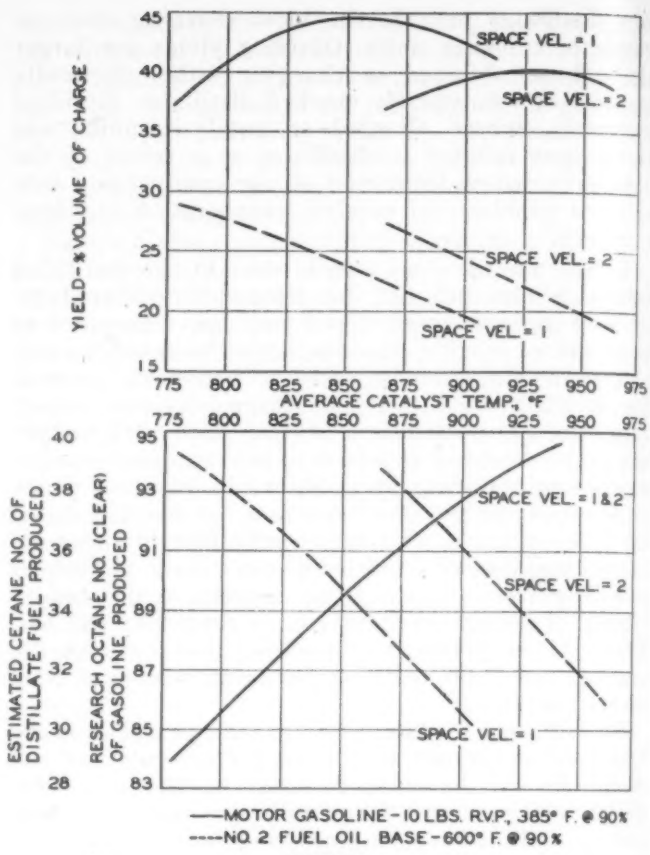

SPACE VEL. = 1
SPACE VEL. = 2
SPACE VEL. = 2
SPACE VEL. = 1
YIELD - % VOLUME OF CHARGE
AVERAGE CATALYST TEMP., °F
SPACE VEL. = 1 & 2
SPACE VEL. = 2
SPACE VEL. = 1
ESTIMATED CETANE NO. OF DISTILLATE FUEL PRODUCED
RESEARCH OCTANE NO. (CLEAR) OF GASOLINE PRODUCED
—MOTOR GASOLINE - 10 LBS. RVP, 385° F. @ 90%
----NO. 2 FUEL OIL BASE - 600° F. @ 90%

FIGURE 9

The Effect of Space Velocity and Reactor Temperature on the Quality and Yield of Products from the Catalytic Cracking of East Texas Heavy Gasoil

factors considered are space velocity (the volume of liquid charge per volume of catalyst per hour) and average reactor temperatures. With increasing reactor temperature, the yield of distillate fuel decreases and the cetane number likewise decreases while both yield and octane number of the gasoline increase to an optimum point and then yield decreases. Low space velocities lend to the severity of cracking and have the same effect on the distillate fuel as high reactor temperatures. It should be stated here that normal space velocities are in the range of 1.0 to 2.0 while practical reactor temperatures are in the range of 850 to 950° F.

Cetane number, as a measure of ignition quality of a fuel in a diesel engine, indicates whether or not some difficulties in engine operation may be expected —whether mis-firing is apt to occur during the starting and warm-up period or during prolonged idling and whether serious knocking will occur. Cetane number has also been used as an index of cold starting ability. This latter factor has perhaps been overemphasized inasmuch as an increase in cetane number of 10 units has been found to be equivalent to only an improvement of 12° F. in minimum starting temperature. Figure 10 indicates that catalytically cracked fuels follow this relationship with straight run fuels.

Unspecified Quality Characteristics

While it may be generally conceded by engine builders and diesel fuel consumers that catalytically cracked fuel oils will meet all *currently specified* requirements for diesel fuel except cetane number, there are reservations surrounding those engine operating characteristics which, to date, have not been

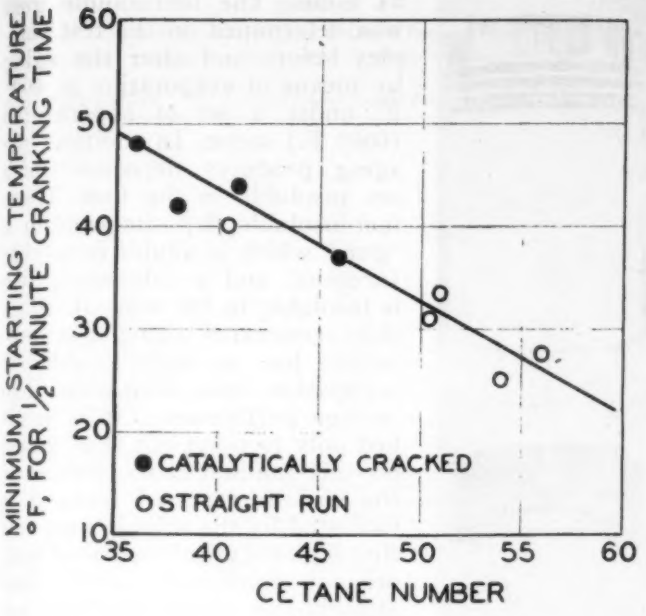


FIGURE 10

Relationship of Cetane Number to Starting Temperature for Various Fuels in a 3-Cylinder, 2-Cycle Diesel Engine.

correlated with chemical and physical test procedures generally used in specifying product quality. There is, for example, fuel stability which has presented only minor problems as long as straight-run distillates have been used. Extensive work on the part of individuals and cooperative groups has yet to produce a test for stability that even a simple majority will accept as significant. There is, too, the question of hydrocarbon composition and its effect on engine deposits and wear. Also, the suspicion has been reported that some unspecified characteristics in addition to fuel volatility affect mileage, smoke and odor. Some data have been obtained to allay the suspicions surrounding ill effects of non-specified characteristics of catalytically cracked fuels. Much of this, related in the following paragraphs, has been obtained cooperatively with engine builders who see the necessity of adapting their equipment to catalytic fuels. More test information is being obtained each day.

Hydrocarbon Composition

There does exist quite a wide variation in hydrocarbon composition among diesel fuels obtained through simple distillation, catalytic cracking and thermal cracking. Table 1 lists the detailed hydrocarbon composition of a straight-run kerosine and a straight-run gas oil from Mid-Continent crude, a straight-run distillate from Coastal crude, together with two catalytic fuels from similar crudes, and a thermally cracked distillate from a mixed charge stock. Major differences in hydrocarbon composition exist in the relatively high aromatic and slightly lower paraffin content of the catalytically cracked stocks. On the other hand, the olefin content of the catalytic stocks is only slightly more than that of the straight-run fuels. The thermally cracked fuel, however, does contain appreciably more olefins and a markedly higher aromatic to paraffin ratio than either the straight-run or catalytically cracked stocks. These data also serve to further emphasize the fact that, when comparing straight-run and catalytically cracked fuels, the charge stock rather than the type of processing is the major factor affecting hydrocarbon composition and consequently the ignition quality of the distillate fuel produced.

In order to show the effect of these differences in hydrocarbon composition or the effect of possible trace components peculiar to the cracked stocks on engine operation, these or similar fuels were run in a single cylinder, 4-cycle supercharged engine for 480 hours under high load and normal temperature conditions. These results, tabulated in Table 2, show that insofar as deposits and wear are concerned, all the fuels perform equally well. Photographs of the pistons from these runs are shown in Figure 11.

Preliminary investigations indicate that when fuels are evaluated under conditions of normal load and low jacket temperature (100° F.) there may be differences in engine wear characteristics attributable to differences in the hydrocarbon composition of the fuels. There has been no great incentive to complete this phase of the investigation inasmuch as engines in the field should not and need not be permitted to operate in such a fashion.

Inasmuch as engines of various types differ in their response to changes in fuel characteristics, further tests were made comparing a straight-run and a catalytically cracked fuel in a 3-cylinder, 2-cycle engine which is reportedly critical with respect to ignition quality and volatility of the fuel. These results which are shown in Table 3 and Figue 12 indicate that when the engine is run at high load and normal engine temperatures are maintained, no knocking is experienced and there is little difference between the performance of the two fuels even though the ignition quality of the catalytically cracked fuel was 18 cetane numbers below that of the straight-run fuel.

Figure 12, which shows the engine parts from this work, indicates that the catalytically cracked fuel may be superior to the straight-run fuel inasmuch as the piston skirts are noticeably different. The differences in the condition of the intake ports is believed to be

TABLE 1

Hydrocarbon Composition and Properties of Distillate Fuels Procured from Different Charge Stocks and Processing

Processing	Straight Run		Thermally Cracked	Catalytically Cracked	
Type of Charge	Mid-Continent	Coastal	Mixed	Mid-Continent	Coastal
Gravity, °API	43.3	36.1	27.4	25.8	33.1	25.4
ASTM Dist., °F.:						
IBP	356	516	438	190	404	424
10 Percent	396	556	508	392	484	456
50 Percent	442	585	556	479	536	500
90 Percent	506	634	627	590	614	582
E. P.	548	680	684	636	660	632
Cetane Number	51	66	37	25	47	24
Pour Point, °F.	—40	25	—70	10	15	—90
Carbon Residue (on 10 Percent Btms.) Weight Percent	Nil	0.03	0.2	0.4	0.09	0.1
Sulfur, Weight Percent	0.07	0.15	0.17	0.13	0.22	0.10
Hydrocarbon Type, Vol. Percent:						
Olefins	2	1	3	7	2	3
Aromatics	13.	16	23	49	26	35
Naphthenes	23	28	61	32	19	50
Paraffins	62	55	13	12	53	12
Total	100	100	100	100	100	100
Hydrocarbon Type, Wt. Percent:						
Aromatic Ring Structure	9	11	18	40	23	30
Naphthenic Ring Structure	20	20	45	28	14	37
Paraffinic Structure*	71	69	37	32	63	33
Total	100	100	100	100	100	100

* Includes olefinic structure which amounts to less than 0.5 percent.

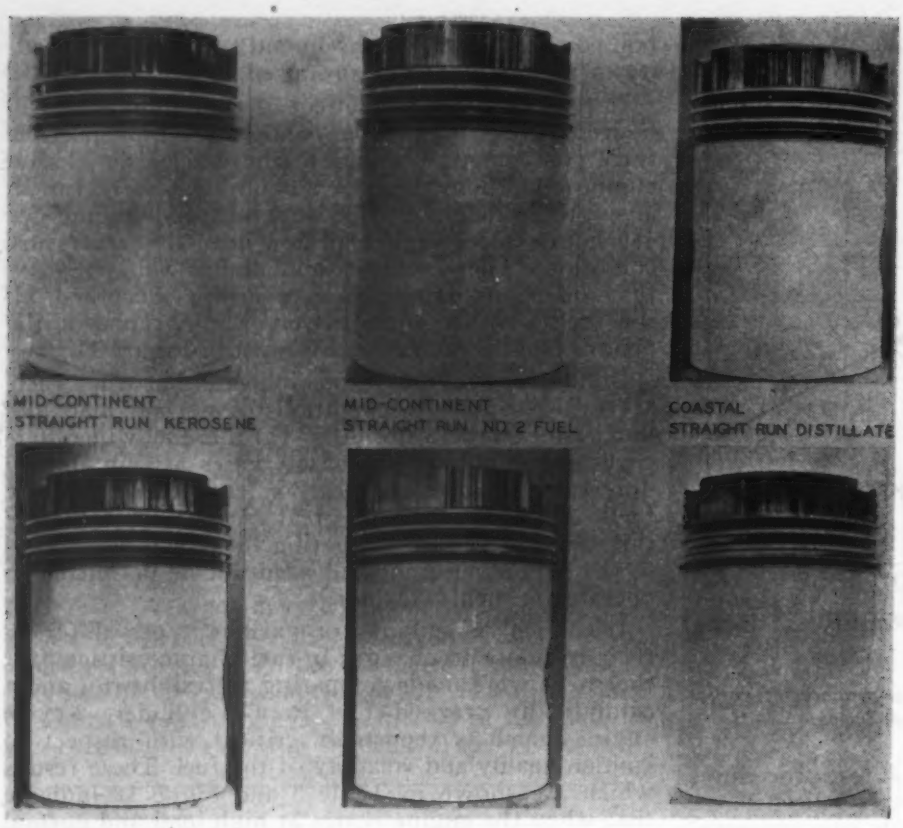

MID-CONTINENT STRAIGHT RUN KEROSENE
MID-CONTINENT STRAIGHT RUN NO. 2 FUEL
COASTAL STRAIGHT RUN DISTILLATE
MID-CONTINENT CATALYTICALLY CRACKED DISTILLATE.
50 PERCENT COASTAL CAT. CRACKED DIST. 50 PERCENT KEROSENE.
50 PERCENT MIXED CHARGE THERMALLY CRACKED DISTILLATE. 50 PERCENT KEROSENE.

FIGURE 11

Pistons from 480-Hour, Laboratory Single-Cylinder, Supercharged, Four-Cycle Engine Tests

more of a function of oil control rather than fuel characteristics.

Fuel Stability

The stability characteristics of distillate fuels have never been well defined. The problem of stability, in the few instances where it has occurred, is usually confined to the fuel system. The correlation of laboratory control tests to field performance in terms of storage stability or engine performance is practically non-existent; however, this subject is currently on the agenda for consideration by cooperative research groups. Some accelerated laboratory test data are available, nevertheless, which should provide some insight to the long-term storage stability characteristics of catalytically cracked stocks.

The primary drawback in discussing data of this type is that there is no universally accepted laboratory procedure for use in predicting the storage stability and determining the preformed "gum," or non-volatile residue, of distillate fuels. With this limitation in mind, it might be concluded from typical data shown in Figure 13 that catalytically cracked fuels are only slightly more unstable than straight-run stocks. Thermally cracked materials, on the other hand, may contain about five times more non-volatile residue than straight run or catalytic stocks after seven days' storage at 170° F. These accelerated data, which have been found to correlate reasonably well with long term storage tests, were obtained by evaporating the test samples at 400° F. at 7mm Hg in an atmosphere of CO_2.

Results of another type of accelerated aging test are given in Table 4. Here the accelerated aging was obtained by placing a test sample in an atmosphere of oxygen at atmospheric pressure and 212° F. for 24 hours. The fuel-soluble gum was determined on the test samples before and after the aging by means of evaporation at 600° F. under a jet of superheated (600° F.) steam. In addition, the aging produces deposits which are insoluble in the fuel. These fuel-insoluble deposits contain a "gum" which is soluble in solvent (acetone) and a sediment which is insoluble in the solvent. Since this accelerated aging test procedure has no well established correlation with long-term field storage performance, it is justified only to point out that, based on this random cross section of the various types of fuels, it is indicated by the soluble gum test that the catalytically cracked fuels are not significantly worse than straight-run stocks and both are appreciably better than some thermally cracked fuels. In this particular group of fuels, only the coastal straight run is borderline in quality. Cracked stocks, both thermal and catalytic, are also sometimes borderline depending somewhat on the severity of cracking.

Mileage

The fuel economy or mileage obtainable from various types of

TABLE 2
480 Hour—Single Cylinder
Supercharged—4-Cycle Engine Tests

FUEL COMPOSITION	Mid-Continent Straight Run Kerosine	Mid-Continent Straight Run No. 2 Fuel	Coastal Straight Run Distillate	Mid-Continent Catalytic Distillate	50 Percent Coastal Catalytic Distillate 50 Percent Kerosine	50 Percent Mixed Charge Thermal Distillate 50 Percent Kerosine
Fuel Properties:						
Gravity, °API	43.0	39.1	27.3	32.6	34.2	33.7
ASTM Distillation, °F.:						
IBP	356	340	424	456	356	224
10 Percent	396	416	508	488	418	398
50 Percent	442	500	552	540	468	458
90 Percent	506	604	630	620	546	542
E. P.	546	664	686	664	609	655
Percent Rec.	98.5	98.5	98.5	99.0	99.0	98.5
Cetane No.	52	50	37	47	37	30
Aniline Point, °F.	154	....	140	151	130	117
Diesel Index	66	....	38	49	44	30
Pour Point, °F.	—40	0	—70	15	Below —30	—5
Viscosity, csks at 100 °F.	1.77	2.55	5.4	3.43	2.18	1.97
Sulfur, Weight Percent	0.07	0.14	0.17	0.23	0.09	0.09
Carbon Residue (10 Percent Btms) Weight Percent	0.02	0.1	0.2	0.05	0.09	0.2
Ash, Weight Percent	Nil	Nil	Nil	Nil	Nil	Nil
Water and Sediment	Nil	Nil	Nil	Nil	Trace	Nil
Engine Test Data:						
Deposits:						
*Piston Ring Belt (100=clean)	73	62	59	60	66	68
Piston Skirt Lacquer	10 Percent Faint Discoloration	30 Percent Faint Discoloration	10 Percent Trace	10 Percent Trace	Nil	10 Percent Trace
Wear:						
Avg. Ring Gap Increase, inches/1000	12	11	10	8	10	10
Avg. Ring Wt., loss, Mg.	284	265	290	285	296	290
Avg. Cylinder Wear, inches/1000	0.9	1.2	0.7	1.0	0.8	0.7

* Based on a system of demerits for deposits.

Engine Operating Conditions—Duration, 480 Hours; RPM, 1200; BHP, 42; Intake Air Press, "Hg Gauge 15; Intake Air Temp., °F. 200; Jacket Inlet Temp, °F. 180; Oil Temp., °F. 175.

TABLE 3

250-Hour 3-Cylinder, 2-Cycle Engine Tests

FUEL COMPOSITION	100 Percent Straight Run	100 Percent Catalytically Cracked
Fuel Properties:		
Gravity, °API	37.2	31.1
ASTM Distillation, °F.:		
IBP	346	370
10 Percent	444	440
50 Percent	506	485
90 Percent	572	572
E. P.	616	625
Cetane Number	53	35
Aniline Point, °F.	151	123
Diesel Index	56	38
Pour Point	−5	−5
Viscosity, csks at 100 °F.	2.64	2.42
Sulfur, Weight Percent	0.3	0.24
Carbon Residue (10 Percent Btms) Weight Percent	Nil	0.08
Ash, Weight Percent	Nil	Nil
Water and Sediment	Nil	Nil
Engine Test Data:		
Deposits, Qualitative:		
Piston Skirt	9 Percent Lt. Carbon 45 Percent Black Lacquer 11 Percent Brown Lacquer 20 Percent Lt. Brown Lacquer	13 Percent Lt. Carbon 23 Percent Black Lacquer 14 Percent Brown Lacquer 24 Percent Discoloration
Piston Ring Grooves	Med. to Hard Carbon	Med. to Hard Carbon
Piston Ring Lands	Med. to Hard Carbon	Med. to Hard Carbon
Piston Crown	Soft Carbon	Light Soft Carbon
Top Land	Hard Carbon	Med. to Hard Carbon
Exhaust Valves	Medium Carbon	Light Soft Carbon
Valve Ports	Medium Carbon	Medium Carbon
Deposits, Quantitative, Grams:		
Exhaust Valves	0.040	0.123
Piston Crown	0.299	0.135
Top Piston Ring Land	0.278	0.674
All Piston Ring Lands	0.855	1.036
Top Piston Ring Groove	0.594	0.707
All Piston Ring Grooves	3.665	3.620

stocks has been found to be related only to the heating value or the API gravity. In this respect, catalytically cracked stocks are slightly heavier than their straight-run counterparts as may be noted from inspection data in Tables 1, 2, and 3. Thus, the cracked stocks should provide the most miles per gallon. The only exception to the correlation of fuel heating value with mileage that has been encountered is in some types of service where engine operating temperatures are allowed to fall below normal and some optimum fuel volatility characteristic may give the best economy performance.

Exhaust Smoke and Odor

Field tests on buses operating on an urban type of schedule (Table 5) have shown that exhaust smoke is related to fuel volatility and has little relation to the type of fuel or cetane number (in the range of 40 to 50 cetane number). Other investigators[1, 2] also claim that exhaust smoke is related, for the most part, to fuel volatility, with there being perhaps some optimum cetane number for a fuel of given volatility characteristics. For current engines and volatility of fuels this value is believed to be in the range of 35-40 cetane number.

Exhaust odor is related to some as yet unidentified factor of fuel composition, particularly in straight-run fuels. Data other than that of Table 5 are also available[1] to show that exhaust odor is not related to volatility or natural cetane number. Lachrymation is a third characteristic of diesel exhaust gases which has been found, in some cases, to be rather severe with straight-run fuels having high front-end volatility.

In some types of service where it is not possible to maintain engine operating temperatures at recommended levels, the low engine temperature will have the same effect as insufficient fuel volatility on increasing exhaust smoke. Most refiners have, in the past, provided premium type (high volatility) fuels for such applications. Most field complaints regarding exhaust smoke in cases where the fuel is at fault

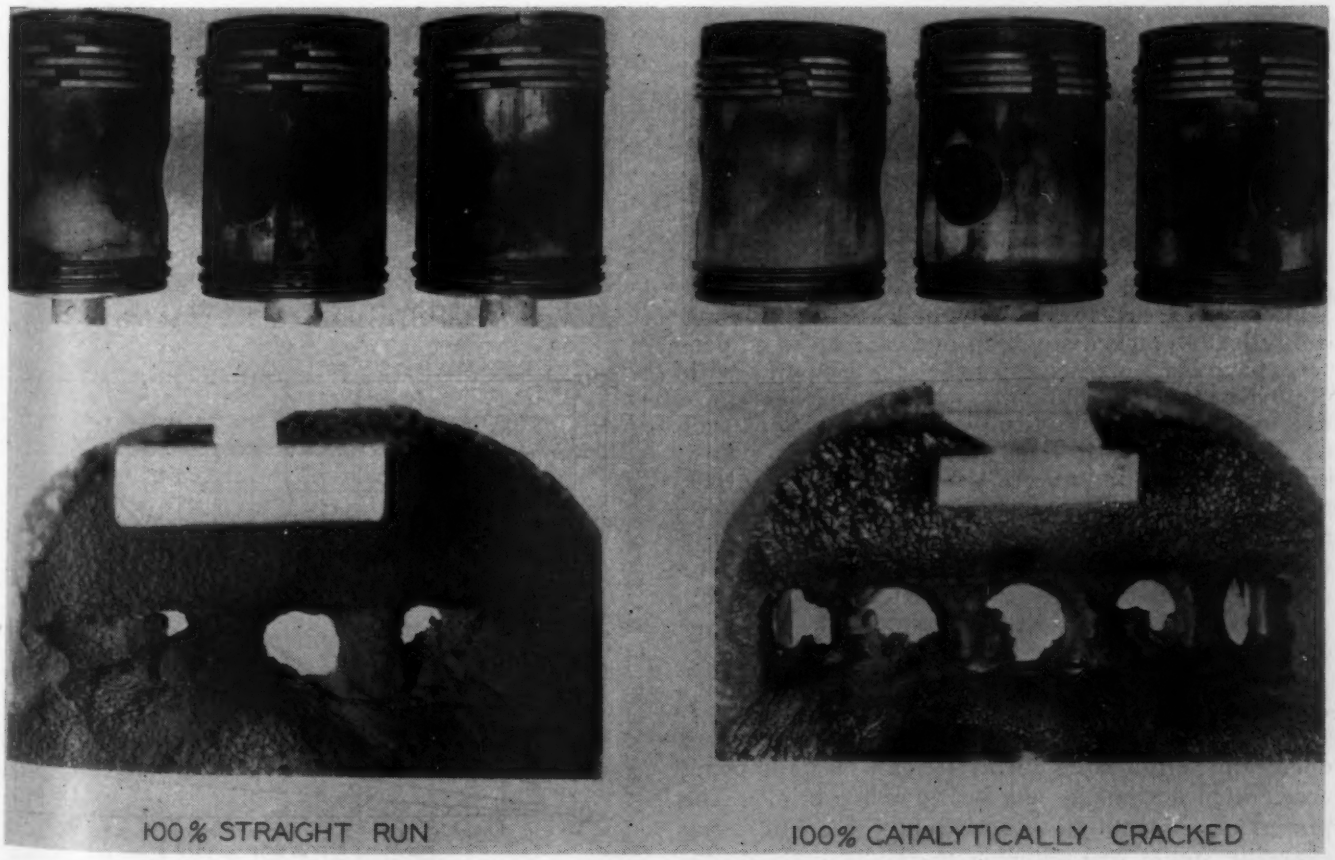


FIGURE 12

Pistons and Intake Ports from 250-Hour, Laboratory Three-Cylinder, Two-Cycle Engine Tests.

TABLE 4

24 Hour Accelerated Aging Tests of Distillate Fuels in O_2 Atmosphere at 212° F.

	Soluble Gum Mg/100 Ml[1]		Fuel Insoluble Deposits After Aging-Mg/100 Ml		
	Unaged Sample	Aged Sample	Solvent Insoluble Sediment	Solvent Soluble "Gum"	Total Fuel Insolubles
Mid-Continent Straight Run	2.0	....	2.1	0.7	2.8
Light West Texas Straight Run	1.0	1.4	0.7	0.1	0.8
Heavy West Texas Straight Run	2.3	3.4	1.5	0.2	1.7
Coastal Gas Oil Straight Run	11.5	15.6	5.1	2.0	7.1
Thermal Gasoil (in drum storage 6 mo. prior to testing)	25.9	69.4	0.8	0.5	1.3
Catalytic Mid-Continent Gasoil	4.5	10.0	1.0	0.5	1.5
Catalytic Coastal Gasoil	7.8	12.4	0.4	0.6	1.0
Catalytic Kuwait Lt. Dist. Fuel	3.8	9.2	1.2	0.5	1.7
Catalytic Kerosine Fraction	0.9	2.6	0.4	0.4	0.8

[1] Evaporated Residue at 600° F.

TABLE 5

Smoke and Odor Field Tests of Diesel Fuels*

Fuel Code	A	B	C	D	E	F
Type of Operation	Urban	Urban	Urban	Urban	Urban	Urban
No. of Buses Tested	3	3	3	3	3	3
Type of Fuel	Mid-Cont. Str. Run	Mid-Cont. Str. Run	Mid-Cont. Str. Run	Naph. Str. Run	Naph. Str. Run	Naph. Str. Run
Gravity, °API	42.5	41.2	36.4	33.6	31.0	31.4
ASTM Distillation, °F.:						
IBP	336	332	355	395	393	356
10 Percent	381	384	434	437	494	442
50 Percent	426	441	518	487	545	524
90 Percent	484	526	594	582	639	630
E. P.	533	600	647	649	714	662
Cetane Number	49	49	51	41	44	43
Exhaust Smoke	Trace	Light	Medium	Medium	Medium	Light
Exhaust Odor	Satisfactory	Satisfactory	Satisfactory	Objectionable	Objectionable	Objectionable

* Buses equipped with 6 cylinder, 2 cycle diesel engines.

are, therefore, usually due to the improper selection of available fuels. Most other causes of field complaints on smoke are due to engine overloading arising either from the mechanical condition of the engine or maladjustment of the fuel injection system, attempting to apply an overrated engine to an underrated job, or from some combination of these factors. When the occasion warrants, the refiner *may be* able to supply the volatile types of fuels needed from catalytic stocks.

Field Experience

Other field tests of an endurance type have been run in intercity buses powered by 6-cylinder, 2-cycle diesel engines on a 40 cetane number catalytically cracked fuel which was raised to 50 cetane number by means of an ignition accelerator. Even though this test fuel was of No. 2 fuel oil volatility, no difference in engine deposits was noted between the test fuel and the control fuel which was a premium grade kerosine type of product. Fuel economy was improved due to the difference in API gravity of the two fuels while driver reaction to engine power response was in favor of the catalytically cracked fuel. (It should be admitted that there is no logical explanation for this reaction.)

The long term performance of catalytically cracked fuels has been found to be entirely satisfactory as evidenced by the fact that in several Eastern and Midwestern areas, 50 cetane number fuels containing catalytically cracked stock, in one case up to 80 percent, have been marketed for the last 9 months with no evidence of any difficulty whatsoever. This practice of including catalytically cracked fractions will no doubt expand, at least to the limit imposed by ignition quality limitations. Distillates from catalytic processing of paraffinic charging stocks can be incorporated in substantial percentages, but current cetane number requirements prevent utilization of significant quantities of catalytic distillates from some intermediate and practically all naphthenic charging stocks.

Conclusions

A trend toward more extensive catalytic cracking operations, originating during the late 30's and being accelerated during the war years, will continue. The preference in catalytic processing for straight-run charging stocks will influence markedly their availability for diesel fuel use. Expanded demands for domestic heating oils as well as diesel fuels will further complicate the supply of uncracked distillates for specific end uses.

The major portion of the catalytically cracked distillates from Houdry and TCC processing may be made to meet all currently specified requirements for high speed diesel engine fuel with the single exception of cetane number which will be some 5 to 15 units below the ignition quality of the gas oil charging stock from which it was derived. Laboratory and field tests that have been conducted to date have indicated that fuel quality characteristics of catalytically cracked fuels, such as hydrocarbon type and stability, have displayed no adverse effect upon engine operation under normal operating conditions. The over-all results from field experience have been most favorable.

There are required more data on the use of catalytically cracked fuels in a greater variety of engines in a greater number of applications. These will be obtained by the petroleum industry and the automotive industry individually and cooperatively. In the course of his participation in these programs, the diesel engine builder should keep in mind that lower ignition quality requirements and less stringent volatility requirements will lead to greatest availability to the diesel engine operator and fuel user.

REFERENCES

[2] "Diesel Engine Exhaust Smoke as Influenced by Fuel Characteristics," H. D. Young—SAE Annual Meeting, January, 1948.

[3] "Smoke in High Speed Diesels," J. J. Broeze and C. Stillebroer—SAE Annual Meeting, January, 1948.

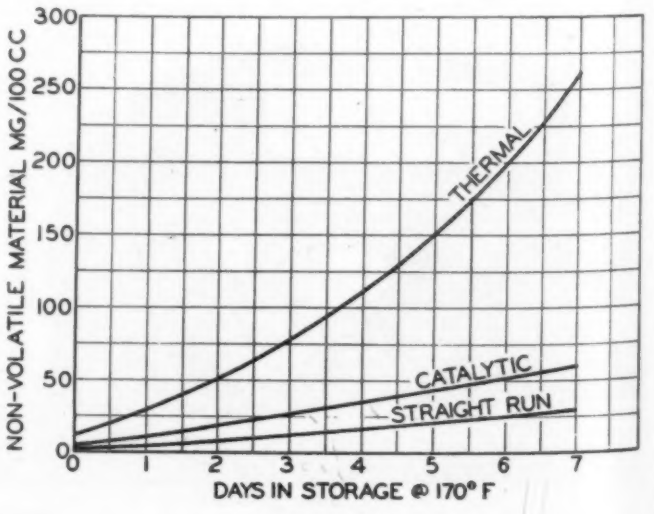


FIGURE 13

Accelerated Storage Tests on Light Distillate Fuel Oil

The Hoover Process—

Use of Oxygen IN Gasoline Treating

CHARLES O. HOOVER, Refinery Specialist
Air Reduction Sales Company, New York

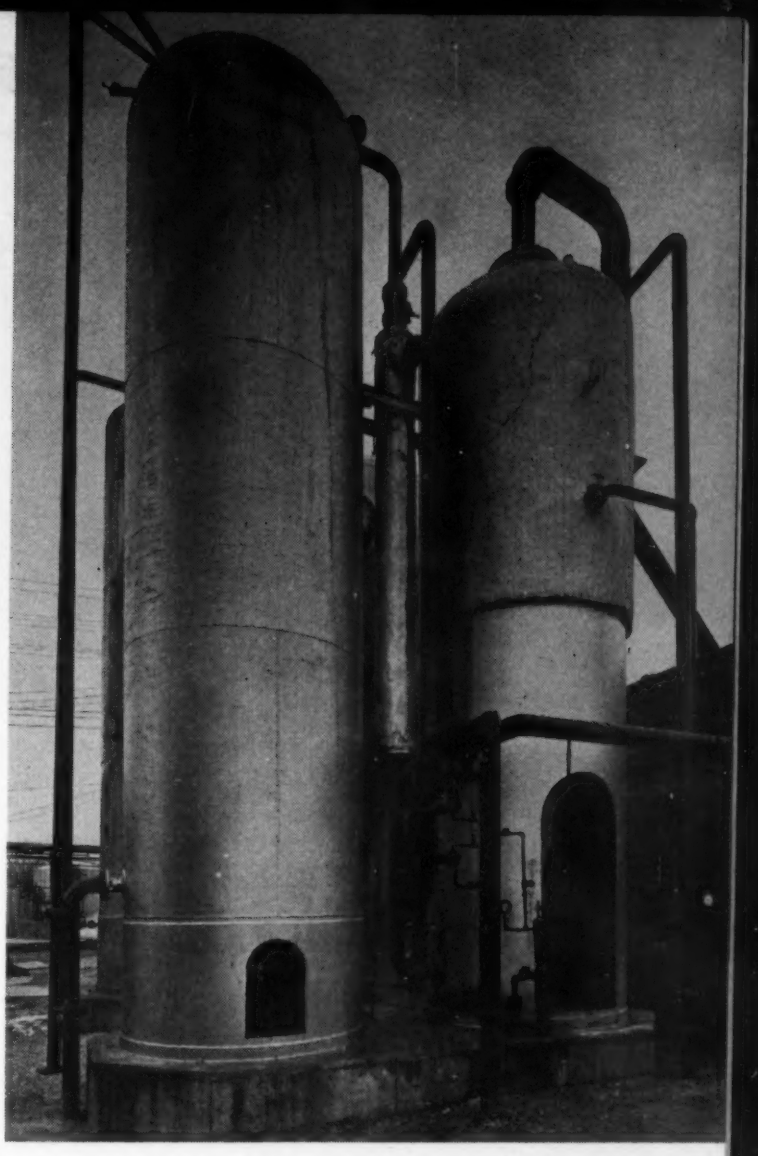
THE conversion of malodorous mercaptan sulfur compounds found in the lower boiling petroleum fractions such as gasoline, naphtha, kerosine, and light gasoils, into compounds with a marketable odor present a special problem to the manufacturer of these products. During the past two decades several methods for converting these sulfur compounds have been used by the industry. While the ultimate result in treating is for the conversion of the corrosive and odoriferous compounds into stable and non-corrosive compounds with a marketable odor, many deleterious effects encountered in the various methods of treatment have resulted in several periods of transition in treating products containing these objectionable compounds.

Several years ago a process utilizing the near catalytic reaction of cupric chloride and oxygen for the conversion of mercaptan sulfurs into stable, noncorrosive disulfides with a marketable odor was offered to the refiner of petroleum products. While the sweetening of these products with cupric chloride in no way improves the quality of the original product as manufactured, products sweetened in this manner, due to the elimination of the deleterious effects encountered other methods, are of higher quality. This is because they suffer no loss in original anti-knock quality, have improved color stability, contain no potential corrosiveness, and have a greater gum stability with smaller amounts of inhibitors.

The sour product is contacted with a slurry of cupric chloride impregnated diatomaceous earth. Finely powdered diatomaceous earth is impregnated with the cupric chloride by mixing the earth and copper salt in a dry state and adding only a sufficient amount of water to allow the cupric chloride to be absorbed by the diatomaceous earth.

Water utilized in impregnating the earth with cupric chloride is dispersed upon the vast surface area presented by the highly porous diatomaceous earth and its physical presence is not discernable. The slurry, prior to contact with oil, has the appearance of a dry fluffy powder and upon being introduced in the oil becomes a highly flocculent precipitate.

This earth acts as a carrier for the cupric chloride and does not enter into the sweetening reaction but the wide dispersal of the cupric chloride-water film upon the hydrophobic earth materially facilitates the reaction between the cupric chloride and the mercaptans present in the oil.



Salt Tower (left) and Reactor Vessel with Preheater and Oxygen Eductor Between.

Typical proportions used in mixing the slurry are 80 percent diatomaceous earth, 10 percent cupric chloride, and 10 percent water.

The initial reaction of cupric chloride with the malodorous mecaptans forms disulfides, cuprous mercaptides, and hydrochloric acid, as shown in the following equation:

$$\underset{\text{Mercaptans}}{4\ R^{*}\text{—S—H}} + \underset{\text{Cupric Chloride}}{2\ CuCl_2} = \underset{\text{Disulfides}}{2\ R\text{—S—S—R}} + \underset{\text{Cuprous Mercaptide}}{2\ R\text{—S—Cu}} + \underset{\text{Hydrochloric}}{4\ Hcl} \quad (1)$$

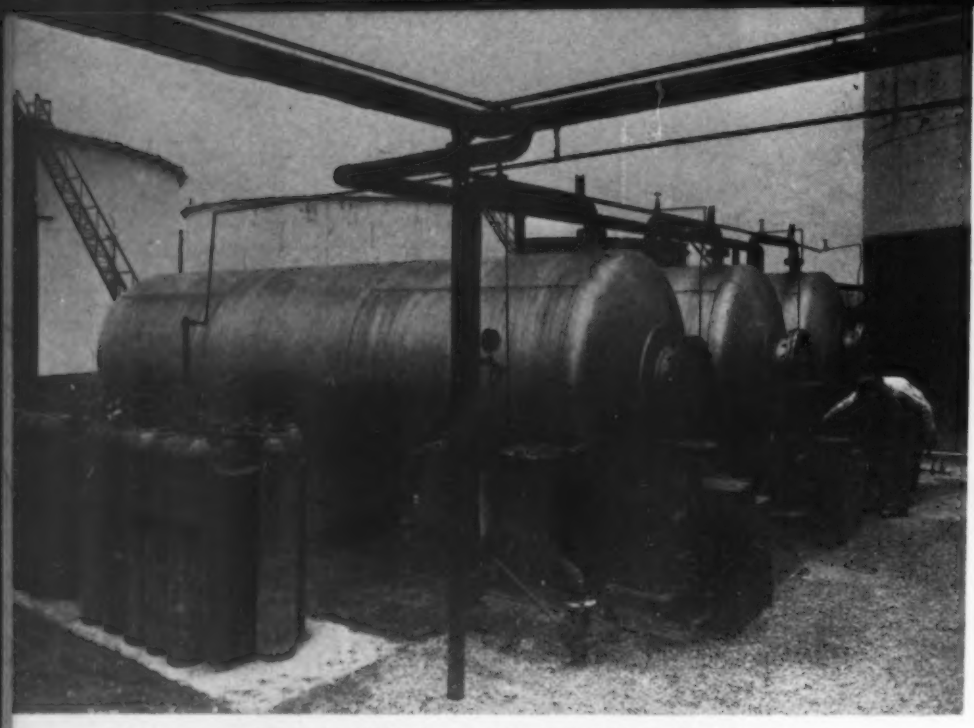
(* The R in the above and following equations represents the methyl, ethyl, propyl, butyl, and amyl mercaptans and their isomers found in the boiling range of the lighter hydrocarbons.)

Additional cupric chloride gives,

$$\underset{\text{Cuprous Mercaptides}}{2\ R\text{—S—Cu}} + \underset{\text{Cupric Chloride}}{2\ CuCl_2} = \underset{\text{Disulfide}}{R\text{—S—S—R}} + \underset{\text{Cuprous Chloride}}{4\ CuCl} \quad (2)$$

Combining the two stages of reaction the equation becomes,

$$\underset{\text{Mercaptan}}{4\ R\text{—S—H}} + \underset{\text{Cupric Chloride}}{4\ CuCl_2} \rightarrow \underset{\text{Disulfides}}{2\ R\text{—S—S—R}} + \underset{\text{Cuprous Chloride}}{4\text{-}CuCl} + \underset{\text{Hydrochloric Acid}}{4\text{-}HCl} \quad (3)$$



Oxygen Manifold Bank and Horizontal Water Wash Vessels

***MERCAPTANS** in refined distillates have been a major refining headache for the past 20 or 30 years. Several methods for converting these malodorous compounds in light hydrocarbon products to obtain marketable products have been utilized. The process described here was developed and patented by the author in 1936, and has been employed in some 40 odd plants since that time. The particular installation reported has been especially satisfactory according to the operators. Cost figures given may be of interest to those who care to make a comparison between this and other processes.*

In each instance the disulfides are stable and do not enter further into the reactions.

Addition of oxygen to the stage resulting in equation (3) gives

$$\underset{\text{Cuprous Chloride}}{4\,CuCl} + \underset{\text{Hydrochloric Acid}}{4\,HCl} + \underset{\text{Oxygen}}{O_2} = \underset{\text{Cupric Chloride}}{4\,CuCl_2} + \underset{\text{Water}}{2\,H_2O} \qquad (4)$$

with oxygen displacing chlorine in the hydrochloric acid to form water, and the release chlorine joining the reduced cuprous chloride to form cupric chloride, the original sweetening reagent.

In actual processing of the sour product a sufficient quantity of oxygen is provided in the product prior to the introduction of cupric chloride and because of this condition it is doubtful if the hydrochloric acid exists other than the infinitesmal time required for its reaction with the oxygen.

The addition of equations (3) and (4) give the simple expression

$$\underset{\text{Mercaptan}}{4\,R{-}S{-}H} + \underset{\text{Oxygen}}{O_2} = \underset{\text{Disulfides}}{2\,R{-}S{-}S{-}R} + \underset{\text{Water}}{2H_2O} \qquad (5)$$

which represents the essential reaction in conversion of the mercaptans and continuous regeneration of the sweetening reagent.

The volume of oxygen required for the treating of various stocks is determined by the quantity of mer-

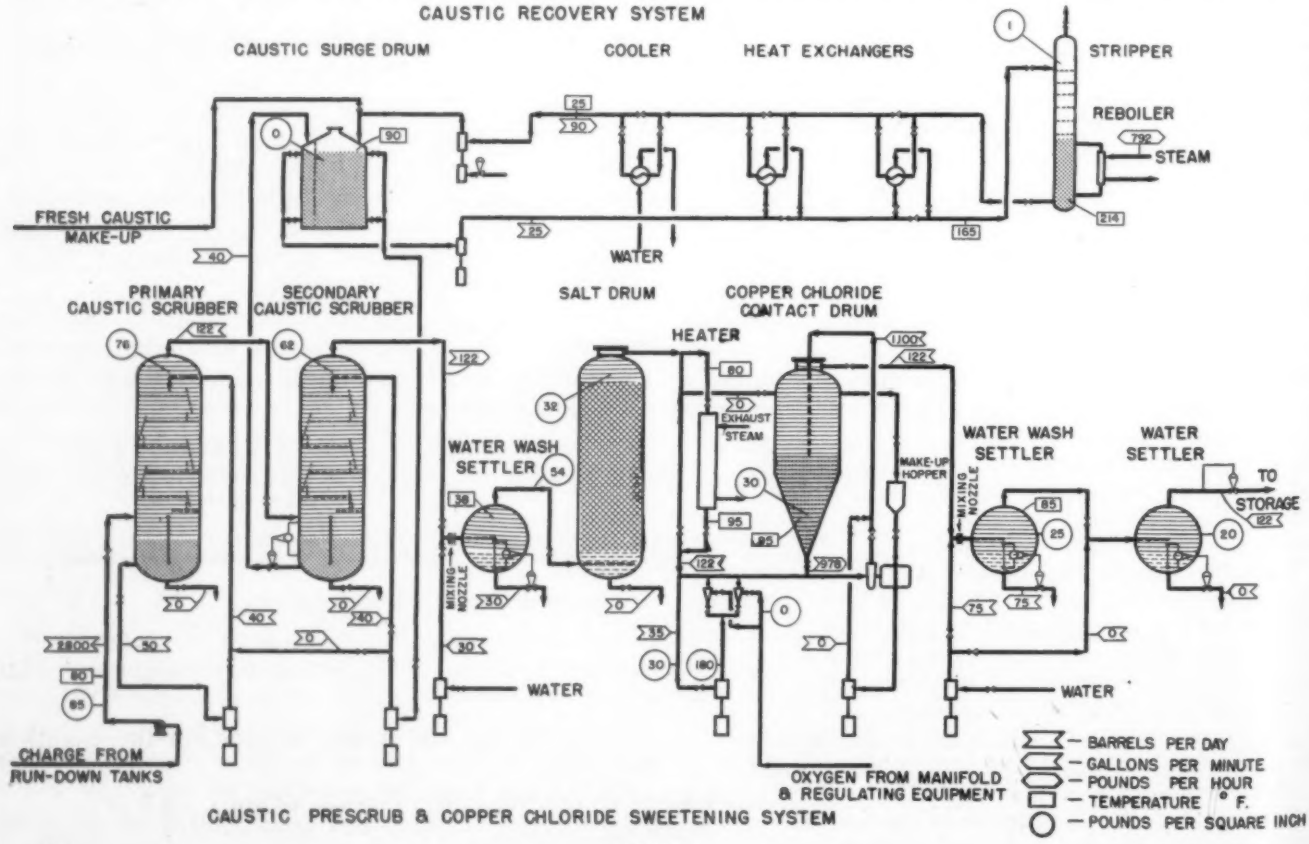


FIGURE 1

captan sulfur in the stocks. The mercaptan content is determined by titrating a given volume of charge stock with a standardized solution of hydrated copper sulfate and ammonium, wherein one milliliter of the copper sulfate-ammonium solution is equivalent to one milligram of mercaptan sulfur. The number of mls. of solution required to equal the quantity of mercaptans in 100 cubic centimeters of oil is referred to as the "copper number" of the oil. Theoretically, 0.01 cubic foot of oxygen will be required to oxidize one copper number barrel of charge stock.

Distillates having as high a copper number as 180 have been treated successfully with the Airco-Hoover Copper sweetening-process and more than 500 million barrels of sour products have been sweetened to date in the various installations throughout the industry.

Typical Installation

A typical installation for the sweetening of light oils by utilizing the foregoing reaction is the installation in the Aetna Oil Company's Louisville, Ky., refinery of an Airco-Hoover sweetening process unit.

This treating unit, installed about seven years ago, has efficiently sweetened some 6 million barrels of sour straight-run gasoline, naphtha, and cracked gasoline.

The unit processes 2800 barrels of sour stock a day and has a design capacity of 5000 barrels per day which is sufficient to allow for expansion in plant capacity. Operating labor consists of one operator per eight-hour shift. The unit is usually operated two eight-hour shifts a day.

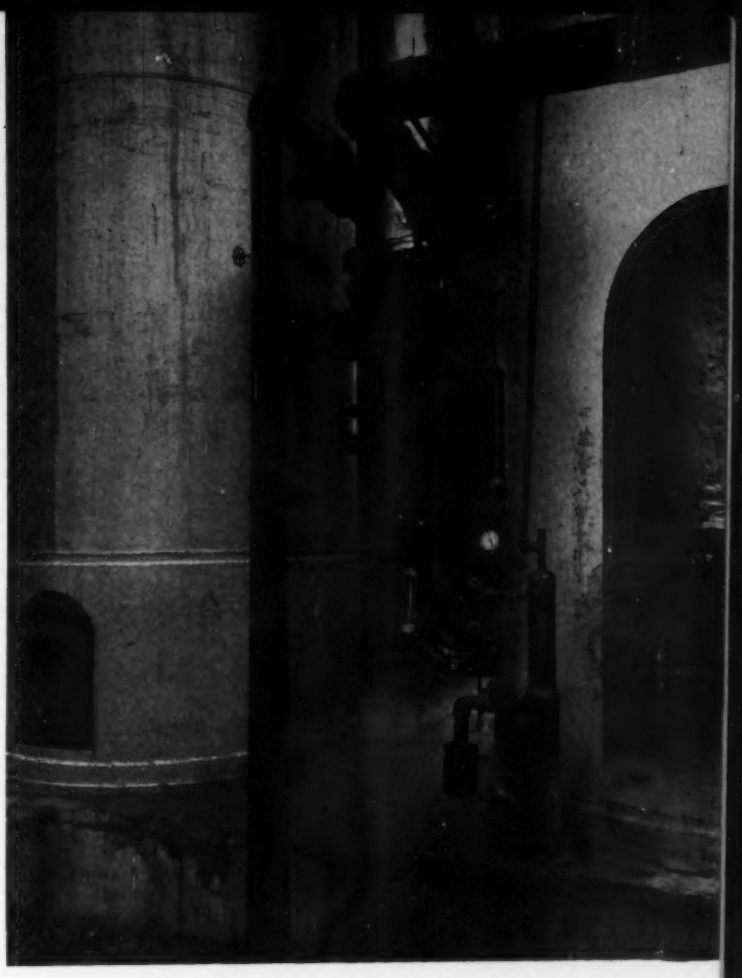
In present treating operations, straight-run sour gasoline and naphtha are blended in specification product proportions before treating. The cracked gasoline and total straight-run charges are treated either separately or may be blended at the charge pump. The unit is never shut down with cracked gasoline in contact with the slurry but enough straight-run product always is reserved to displace the cracked stock from the system.

Steps in treating products by this method include prescrubbing of the charge with a caustic soda solution for the removal of hydrogen sulfide and lighter molecular weight mercaptans, water washing to remove caustic carry-over from the prescrubbers, removing of the entrained water by salt drying, introduction of oxygen for regeneration purposes, contacting charge product with the sweetening reagents, and a final waterwash to remove the mechanical carry-over of the sweetening chemicals.

In preparation for contacting the charge stock with the sweetening reagent, Figure 1, the charge is pumped through a primary scrubber in which an 18-20° Beaumé caustic-soda solution is circulated counter-currently to the sour charge stock for the removing of hydrogen sulfide, organic acids and a portion of the lower molecular weight mercaptans.

The scrubber vessel is equipped with five bubble-trays with round cast iron caps (Figure 2) and provides efficient commingling of the charge stock with the caustic solution. The scrub solution is circulated from the bottom to the top of the scrubber and is recirculated until the scrubbing power of the solution is reduced to an inefficient level by the accumulation of acid oils and dilution from water entrained in the charge stock.

The hydrogen sulfide-free charge stock then enters

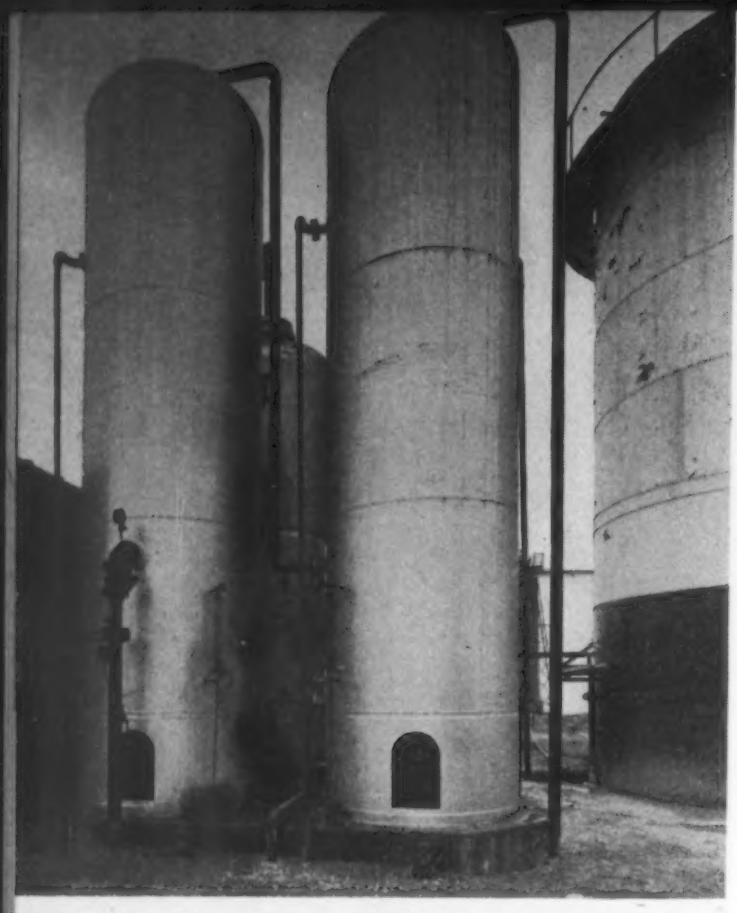


Oxygen Eductor Manifold Showing Mercury Seal Installation to Prevent the Possibility of Oil Backing Up Into the Oxygen System

a secondary scrubber similar in construction to the primary scrubber, where additional removal of mercaptan sulfur occurs. Flow of charge stock through this scrubber is also counter-current to the scrub solution and the effectiveness of the over-all removal of mercaptans from cracked distillates is approximately 50 percent of the total mercaptan sulfur content of the original charge. Removal of mercaptans from straight-run products is somewhat lower. The 18-20° Beaumé caustic-soda scrub solution used in the secondary scrubber is continuously regenerated by circulating the scrub solution through a steam stripping tower with reboiler. In effect, the secondary scrubber provides a multiplicity of washings, wherein the charge being scrubbed is continually being contacted with fresh scrub solution. Mercaptans removed from the charge stock are stripped from the scrub solution and burned in the stills.

Upon leaving the secondary scrubber, the charge

FIGURE 2
Type of Bubble Cap Used in Aetna Caustic Scrubbing Tower



Primary and Secondary Caustic Scrubbers for the Removal of Hydrogen Sulfide and Soluble Mercaptans

stock is given a water-wash to remove any caustic carry-over from the prescrubbers. The charge stock is mixed with water through a special type nozzle to provide intimate contact with the charge and is allowed to settle in a horizontal wash drum. An automatic level regulator controls the withdrawal of the water from the settling drum. After the water wash, the charge is percolated upward through a vessel containing approximately 15 tons of rock salt to remove the entrained water. The aqueous salt solution accumulating in the vessel is periodically drawn off at the bottom to insure maximum drying efficiency.

Upon leaving the salt drum a small portion of the charge stock is diverted through a steam pressure pump to provide a pressure differential for operation of the oxygen eductor. A pressure differential of approximately 150 pounds is maintained. The eductor feeds oxygen into the charge stock stream at a controlled rate from a manifolded bank of cylinders. The oxygen is utilized to effect regeneration of the sweetening reagent. To provide protection against the possibility of either excessive oxygen entering the charge stream, or the charge stream entering the oxygen manifold system, a mercury seal and a series of check-valves are provided in the oxygen system.

Prior to the introduction of oxygen into the major charge stream, the charge is heated by an exhaust steam preheater to increase the solubility of the water in the charge stock. Optimum conditions vary depending upon the type of stock being treated, but usually a 10° F. increase in temperature over the temperature of the charge stock is adequate to remove the water which forms during the sweetening reaction. Should an excess of water be allowed to accumulate in the reactor, the diatomaceous earth used as a carrier will become saturated and possibly plug the slurry circulating system.

The sour charge stock-oxygen mixture is contacted with the cupric chloride, and diatomaceous earth slurry from the bottom of the funnel shaped reactor. The sweetening reaction occurs instantly, the mercaptan sulfur forming copper mercaptides which are in turn converted into disulfides which have a marketable odor.

Minimum Mechanical Carry-Over

The slurry-charge stock mixture is pumped by a centrifugal pump to the reactor where the slurry settles to the funnel-shaped bottom and is reintroduced into the untreated charge stream. The hindered settling of the flocculent slurry produces a slurry-free effluent at the top of the reactor. By maintaining optimum conditions a minimum of mechanical carry-over occurs and any carry-over which does occur is removed by a final wash-water.

A second wash drum is available but is used as a water settling drum at present.

A breakdown of one month's chemical costs used in treating 84,000 barrels of sour products is given in the following table.

TABLE 1

CHEMICALS	Quantity Used	Unit Cost	Total
Copper Chloride	330 lbs.	$0.177/lb.	$ 58.00
Diatomaceous Earth	800 lbs.	0.054/lb.	43.00
Oxygen	34,600 cu. ft.	.0085 cu. ft.	294.00
Caustic Soda	6,000 lbs.	0.028/lb.	168.00
Salt	5,000 lbs.	0.825 cwt.	41.00
			$604.00

These figures reflect a chemical unit cost of .719 cents a barrel or about 0.17 mill per gallon.

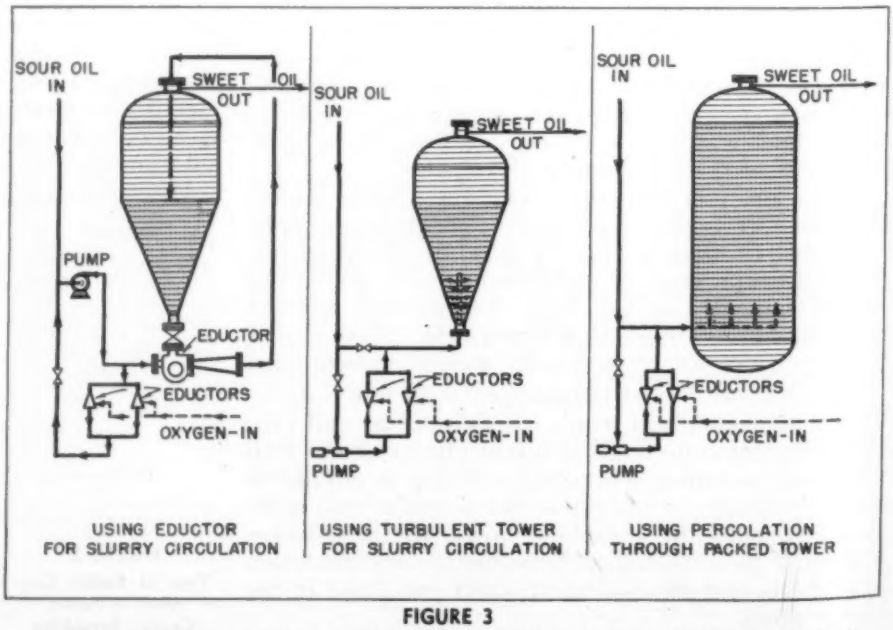


FIGURE 3

Variations of Equipment Installations for Bringing the Slurry in Contact with Sour Oil Stock

Total operating cost for the same period is presented in Table 2.

TABLE 2*

	Per Month	Per Barrel
Insurance and Taxes	$ 41.00	0.049¢
Administration and Supervision[1]	225.00	0.268¢
Operating Labor[2]		
312 hours at $1.85 per hour	577.00	0.687¢
Repair Labor[3]		
128 hours at $1.70 per hour	218.00	0.260¢
Repair Material[4]	138.00	0.164¢
Operating Supplies		
Miscellaneous items such as recording charts, light bulbs, etc.	20.00	0.024¢
Chemicals—From Table 1	604.00	0.719¢
Utilities		
Electricity—9360 kwh @ $.0125/kwh $ 117.00		
Water—150 gpm x 520 hours @ $.0075 per thousand gallons 35.00		
Steam—3500 lb./hr. x 520 hrs. x $0.65 per thousand pounds $1,183.00	1,335.00	1.589¢
Product Losses[5]	86.00	0.102¢
	$3,244.00	3.862¢

Cost per gallon, 0.919¢.

* Basis: Unit operated 15–8 hour shifts a week, 65 shifts a month for a total of 520 hours a month.

1—Supervised other operations, approximately 5% of time charged to copper treater.

2—Operator performs other duties with 60 percent of his time charged to copper treater.

3—Calculated from yearly repair costs figures and the average hourly rate for plant maintenance crew.

4—Calculated from yearly cost figures.

5—Losses incurred by product carry-over in scrubbing and water-washing.

Caustic Regenerating Installation with Mercaptan Stripping Tower and Heat Exchangers in Foreground

These tables reflect a treating cost of .09 cents per gallon of product which is much lower than those of other methods. This, coupled with the ease of operation, the elimination of deleterious effects encountered with other methods, and the resultant sustained quality of treated products, offers the refiner an excellent method for sweetening malodorous oils.

There are several variations of equipment installation to meet requirements of different stocks or to suit the preference of refiners. In any case, the method of bringing the slurry into contact with the sour oil is the main interest. Figure 3 shows modifications of the method by which the sour stock is brought into contact with the copper chloride.

While the basic principles of the scrubber and regeneration systems of Aetna's installation are conventional, several interesting original features are included that are not found in the other installations of this treating process.

Use of Bubble Trays

Most unusual is the use of bubble trays in the scrub towers instead of the commonly used mixing heads or packed towers.

The scrub towers each contain five bubble trays. Each tray is fitted with 70 bubble caps. Intimate contact between the scrub solution and sour charge stock results in an efficient removal of hydrogen sulfide and mercaptans.

Manholes for tray inspection and maintenance are equipped with hinged heads to facilitate maintenance operations.

The primary scrubber solution is circulated by a steam pump from the bottom of the scrubber to the vessel's top tray. This solution when exhausted is discarded, and fresh make-up is added from the secondary scrubber system.

In the secondary scrubber system, the caustic solution is pumped from a surge drum to the top tray of the secondary scrubber and flows under pressure of the treating system from the bottom of the scrub vessel back to the surge drum. An automatic level control maintains a constant level in the bottom of the scrubber and controls the return rate of flow to the surge drum.

The returned solution in the surge drum is continuously circulated through a stripping tower where the mercaptans are removed. The solution enters the stripping tower near the top and flows downward through six stripping trays. A steam heated reboiler provides the heat necessary for stripping the mercaptans from the solution. The mercaptans are removed overhead from the tower and burned in the stills.

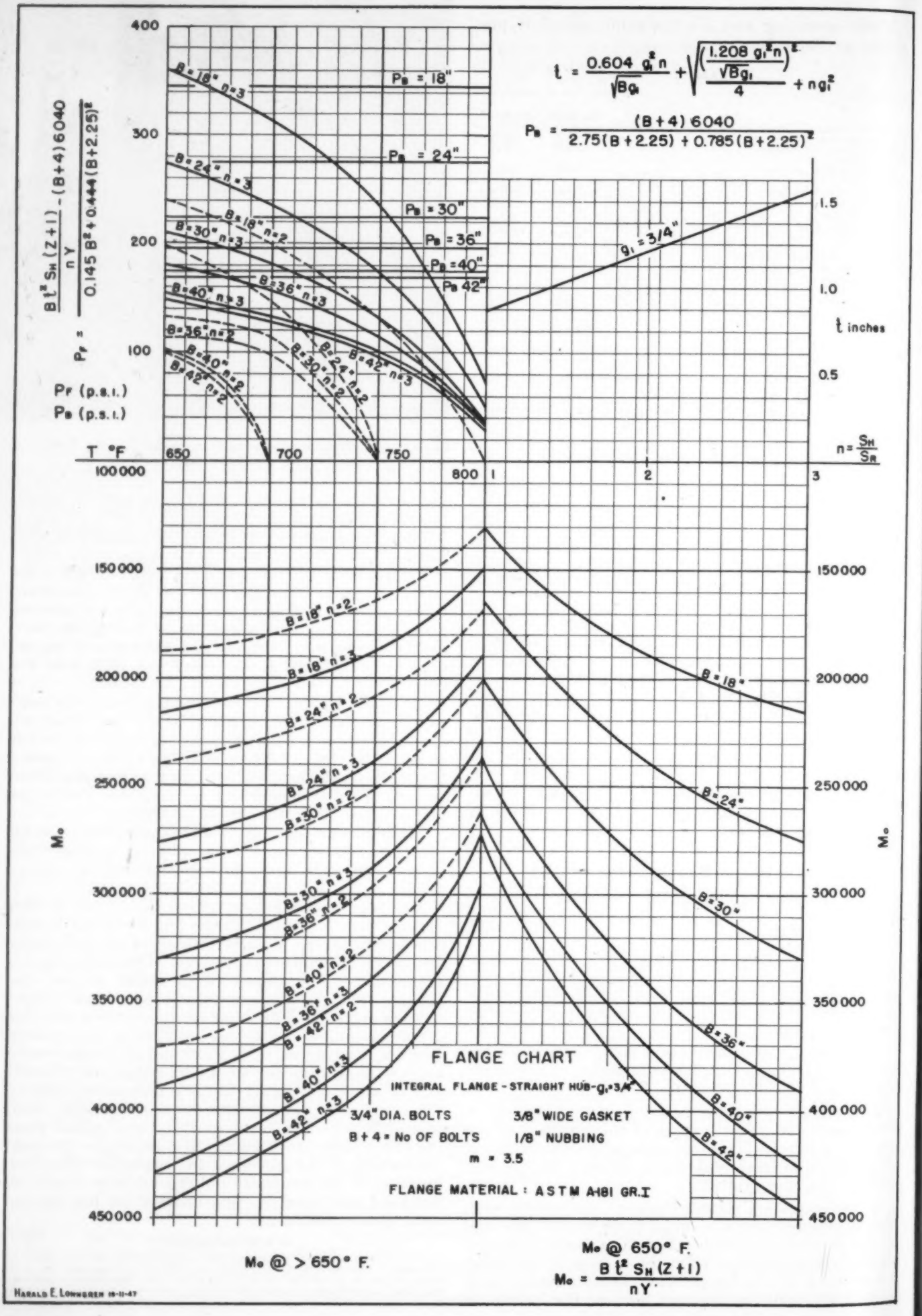
From the bottom of the stripping tower the mercaptan-free solution passes through two heat exchangers where a portion of the regeneration heat is imparted to the incoming solution to the stripping tower. From the heat exchangers the regenerated solution is further cooled in a water cooled exchanger and pumped back into the surge drum.

Fresh caustic make-up is added periodically to replace the solution used in the primary scrubber and losses incurred by carry-over in scrubbing the charge stock.

The sour naphthas and gasolines treated in this unit are produced from Illinois and Southern Louisiana crudes having a sulfur content of approximately 0.35 and 0.15 percent respectively. The cracked gasolines have copper numbers of about 40 and the straight-run gasolines and naphthas have copper numbers of around 20. After being scrubbed with the caustic solutions the copper number of the cracked gasolines is reduced to 18 to 20 and the copper numbers of the straight run stocks are reduced to 12 to 15. The efficiency of the scrubbers is materially aided by the continuous regeneration of the scrubbing solutions. The effective removal of the mercaptans from the raw charge stock greatly facilitates the chemical sweetening of the gasolines and naphthas. The combination of the scrubbers and regeneration system as designed and used in this installation has proven more than satisfactory.

ACKNOWLEDGMENT

The author wishes to express his appreciation to Mr. Clive M. Alexander and Mr. Walter Norman of Aetna Oil Company for their cooperation in providing the operating and cost information concerning the Airco-Hoover copper sweetening process installation at their Louisville, Ky., refinery.


$t = \frac{0.604\, g_1^2 n}{\sqrt{B g_1}} + \sqrt{\left(\frac{1.208\, g_1^2 n}{\sqrt{B g_1}}\right)^2 \frac{1}{4} + n g_1^2}$
$P_s = \frac{(B+4)\,6040}{2.75(B+2.25) + 0.785(B+2.25)^2}$
$P_f = \frac{B t^2 S_H (Z+1)}{nY} - \frac{(B+4)\,6040}{0.145\, B^2 + 0.444(B+2.25)^2}$
Pf (p.s.i.)
Ps (p.s.i.)
T °F
650
700
750
800
400
300
200
100
P_s = 18"
P_s = 24"
P_s = 30"
P_s = 36"
P_s = 40"
P_s 42"
B = 18" n = 3
B = 24" n = 3
B = 18" n = 2
B = 30" n = 3
B = 36" n = 3
B = 40" n = 3
B = 36" n = 2
B = 40" n = 2
B = 42" n = 3
B = 30" n = 2
B = 24" n = 2
B = 42" n = 2
g_1 = 3/4"
1.5
1.0
0.5
t inches
$n = \frac{S_H}{S_R}$
1
2
3
100000
150000
200000
250000
300000
350000
400000
450000
M_o
B = 18"
B = 24"
B = 30"
B = 36"
B = 40"
B = 42"
FLANGE CHART
INTEGRAL FLANGE - STRAIGHT HUB - g_1 = 3/4"
3/4" DIA. BOLTS
B + 4 = No OF BOLTS
3/8" WIDE GASKET
1/8" NUBBING
m = 3.5
FLANGE MATERIAL : A S T M A-181 GR.I
M_o @ > 650° F.
M_o @ 650° F.
$M_o = \frac{B t^2 S_H (Z+1)}{nY}$
HARALD E. LONNGREN 10-11-47

Further Flange Considerations

HARALD E. LONNGREN, Mechanical Engineer, New York

CONTINUING the treatment of flange design calculation methods given in earlier articles, the author here presents, first, a flange design chart which is typical for integral flanges with straight hubs, and secondly, a procedure for the design of flanges for obround manheads.

Considering first the flange design chart, similar diagrams can readily be worked out for flanges with tapered hubs. From charts of this type designers can determine the most suitable value of hub thickness at the back of a flange, g_1, when specified temperatures and pressures are spotted for each size of flange. In addition, stress distributions are readily available.

In connection with his treatment of flange design for obround openings, the author prefaces his work with a statement that, within his knowledge, "there is no public, authoritative, method for calculating the required flange thicknesses. To satisfy this need for a readily comprehensible calculation method a new approach to the problem is presented here which should prove a welcome aid to designers of pressure parts."

An article dealing with stress distribution in integral type flanges appeared in the November, 1947, issue of *Petroleum Refiner*, and a second article treating the several factors to be considered in the practical design of integral flanges was published in the January, 1948, issue. Reference to these articles should be made for nomenclature used in this present article, and for further information on design procedures.

Flange Design Chart

THE flange chart on the opposite page has been worked out for an integral flange with a ¾" thick straight hub. It is based upon the following formulas,

$$\text{Flange thickness: } t = \frac{.604 g_1^2 n}{\sqrt{B g_1}} + \sqrt{\frac{\left(\frac{1.208 g_1^2 n}{\sqrt{B g_1}}\right)^2}{4} + n g_1^2} \qquad (1)$$

$$\text{Total moment: } M_o = \frac{B t^2 S_H (Z+1)}{n Y} \qquad (2)$$

$$\text{Maximum allowance pressure on flange: } P_F = \frac{\frac{B t^2 S_H (Z+1)}{n Y} - (B+4)\,6040}{.145 B^2 + .444 (B + 2\tfrac{1}{4}")^2} \qquad (3)$$

$$\text{Maximum allowance pressure on bolts: } P_B = \frac{(B+4)\,6040}{2.75 (B + 2\tfrac{1}{4}") + .785 (B + 2\tfrac{1}{4}")^2} \qquad (4)$$

in which

B = Inside diameter of flange
g_1 = Thickness of hub at the back of the flange
$n = \frac{S_H}{S_R}$ = Stress distribution factor (S_H = 22,500 psi at 650° F.)
t = Thickness of flange
M_o = Total moment in flange
Z & Y = Flange factors per chart in codes
P_F = Maximum allowance pressure on flange = p = design press
P_B = Maximum allowance pressure on bolts
$(B+4)$ = Number of bolts
6040 = Load per one ¾" diameter bolt
Gasket data: ⅜" wide gasket — ⅛" nubbing
$m = 3.5$

How to use the chart:

Assumed design conditions,
design press. 210 psi
design temp. 650° F
Ins. dia. = 30"

By using the $B = 30"$ pressure curves in the upper lefthand quadrant it will be seen that the design condition calls for a stress distribution factor of $n = 3$. The corresponding flange thickness is found from the graph in the upper right hand quadrant—in this case, $t = 1\text{-}9/16"$.

If, on the other hand, the

Design pressure = 118 psi.
Design temperature = 700° F.

It will be found that $n = 2$ and that the required flange thickness again is equal to 1.19".

For the first mentioned design case the maximum allowance total moment $M_o = 330{,}000$ and in the latter case $M_o = 275{,}000$.

The maximum allowance pressure on the bolting is in both cases equal to 226 psi.

Similar charts can readily be worked out for other values of g_1.

For integral flanges with tapered hubs the formula for t is,

$$t = \frac{.665 F g_1^2 n}{\sqrt{B g_o}} + \sqrt{\frac{\left(\frac{1.33 F g_1^2 n}{\sqrt{B g_o}}\right)^2}{4} + n g_1^2} \qquad (5)$$

Obround Manheads

IT IS readily appreciated that the straight portion of an obround manhead flange cannot be treated in the same manner as the round portion.

This new method of calculating flanges of this type is based upon the fact that the bolt load in the straight portion of such flanges tends to rotate this portion more readily.

From the appended sample calculations it will readily appear that the moment of the couple in the

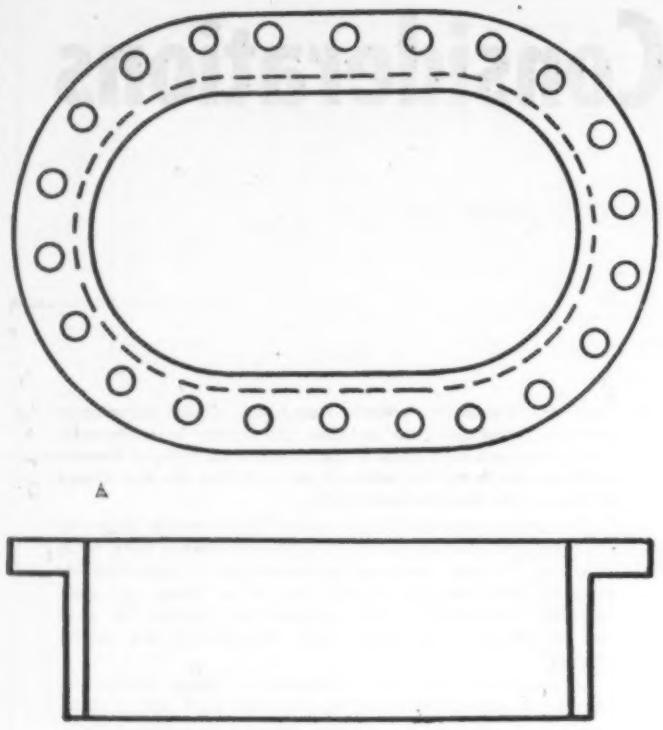


FIGURE 1

straight flange portion is dominating because it is necessary to use rather large bolts (1 inch diameter) so as to guard against abuse.

For the sake of simplicity only, standard forged steel obround manheads of the following sizes (all in inches), 12 x 18, 12 x 20, and 12 x 24, will be considered here.

It is a well known fact that the API-ASME code permits the use of a flange design bolt load "W" which is equal to the average of the minimum required (W_{MIN}) and actual bolt load (W_{ACT}).

The magnitude of the actual bolt load depends upon the bolt material and the number of bolts used. This number is standardized. There are

20 — 1-inch bolts in a 12 x 18-inch manhead.
20 — 1-inch bolts in a 12 x 20-inch manhead.
22 — 1-inch bolts in a 12 x 24-inch manhead.

Thus, the actual bolt loads are:

Carbon Steel Bolts

W_{ACT} = 75,600-pound 12 x 18-inch manhead
= 75,600-pound 12 x 20-inch manhead
= 83,300-pound 12 x 24-inch manhead

Alloy Steel Bolts

W_{ACT} = 220,400-pound
= 220,400-pound
= 242,400-pound

For internal pressures below 160 psi at a maximum temperature of 450° F. it is customary to use carbon steel bolts and a compressed asbestos gasket.

For higher pressures and temperatures the API-ASME code prescribes alloy steel bolts. The gasket may be of any suitable material.

In this analysis a ½-inch wide ring gasket is used. See Figure 2.

First of all it is necessary to establish the value of W, the design bolt load, for the flange as such.

Design Case 1.

In this case alloy steel bolts are used with a ½-inch wide steel jacketed, asbestos filled gasket.

(b = .25 ; m = 3.5 ; y = 8000)

Thus,

$$H_{GY} = (\pi \times d + 2 \times a) \times b \times y$$

in which expression

a = length of straight portion.

For 12 x 18-inch manhead
$H_{GY} = (\pi \times 14.625 + 2 \times 6) \times .25 \times 8000 = 116{,}000$
For 12 x 20-inch manhead
$H_{GY} = (\pi \times 14.625 + 2 \times 8) \times .25 \times 8000 = 124{,}000$
For 12 x 24-inch manhead
$H_{GY} = (\pi \times 14.625 + 2 \times 12) \times .25 \times 8000 = 140{,}000$
For 12 x 18-inch manhead
$H_{GP} = (\pi \times 14.625 + 2 \times 6) \times .5 \times 3.5 \times p = 101.5\ p$
$H = (168 + 87.75) \times p = 255.75\ p$
$H_{GP} + H = 357.25\ p$
For 12 x 20-inch manhead
$H_{GP} = (\pi \times 14.625 + 2 \times 8) \times .5 \times 3.5 \times p = 108.5\ p$
$H = (168 + 117) \times p = 285\ p$
$H_{GP} + H = 393.5\ p$
For 12 x 24-inch manhead
$H_{GP} = (\pi \times 14.625 + 2 \times 12) \times .5 \times 3.5 \times p = 122.5\ p$
$H = (168 + 175.5) \times p = 343.5\ p$
$H_{GP} + H = 466\ p$

In this analysis it will be considered that the following pressure limitations will not be exceeded,

357.25 p = 116,000
p = 325 psi for 12 x 18-inch manhead.
393.5 p = 124,000
p = 315 psi for 12 x 20-inch manhead.
466 p = 140,000
p = 300 psi for 12 x 24-inch manhead.

This means that $H_{GY} = W_{MIN}$ for all manheads. Thus the design bolt load per lineal inch, along the center line of the gasket, is,

$$W = \frac{W_{MIN} + W_{ACT}}{2 \times L}$$

in which expression,

L = length of gasket.

Thus,

$$W = \frac{116{,}000 + 220{,}400}{2 \times 58} = 2900 \text{ pounds for 12 x 18-inch manhead}$$

$$= \frac{124{,}000 + 220{,}400}{2 \times 62} = 2775 \text{ pounds for 12 x 20-inch manhead}$$

$$= \frac{140{,}000 + 242{,}400}{2 \times 70} = 2725 \text{ pounds for 12 x 24-inch manhead}$$

A reasonable average figure is 2750 pounds per lineal inch. This value for W applies to all manhead flanges under consideration.

Design Case II:

In this case carbon steel bolts are used with a ½-inch wide compressed asbestos gasket.

(m = 2.5 ; b = .25 ; y = 4500)

Thus,

$H_{GY} = (\pi \times 14.625 + 2 \times 6) \times .25 \times 4500 = 65{,}250$
for 12 x 18-inch manhead.

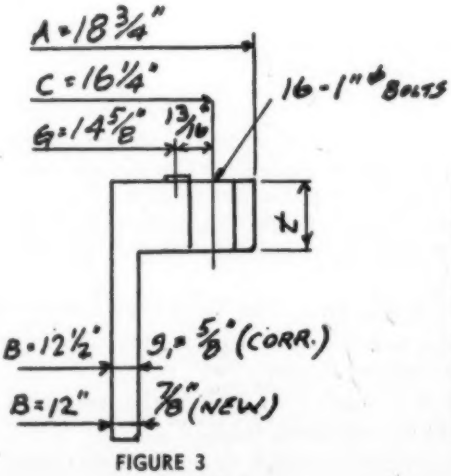


FIGURE 3

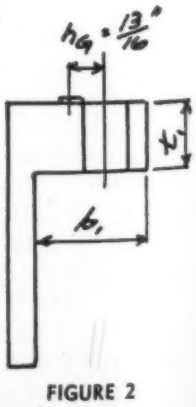


FIGURE 2

$= (\pi \times 14.625 + 2 \times 8) \times .25 \times 4500 = 69{,}750$
for 12 x 20-inch manhead.
$= (\pi \times 14.625 + 2 \times 12) \times .25 \times 4500 = 78{,}750$
for 12 x 24-inch manhead.

In this case the maximum allowable internal pressure is 160 psi. This means that the H_{GY} load is governing, that is, $H_{GY} = W_{MIN}$ for the flange proper for all manhead sizes. Thus, the design bolt load per lineal inch, along the center line of the gasket is,

$$W = \frac{65{,}250 + 75{,}600}{2 \times 5} = 1240 \text{ pounds for 12 x 18-inch manhead}$$

$$= \frac{69{,}750 + 75{,}600}{2 \times 62} = 1170 \text{ pounds for 12 x 20-inch manhead}$$

$$= \frac{78{,}750 + 83{,}300}{2 \times 70} = 1150 \text{ pounds for 12 x 24-inch manhead}$$

A reasonable average figure is 1150 pounds per lineal inch for all manhead flanges.

Calculations:

With the thus established flange design bolt load a designer then proceeds to calculate the flange proper. The required calculation steps are,

1) Determine the required thickness of the round flange portion.
2) Determine the required thickness of the straight flange portion.

It is to be kept in mind that the maximum allowable stress in the straight portion (in the junction section with the round portion) cannot exceed the maximum allowable S_R or S_T stress as calculated for the round portion. (These stresses should preferably be equal to S_F, that is, $n = 1$.)

Round Flange Portion

This portion can, of course, be calculated in the known manner per the API-ASME code. However, a designer will find that the following formula for the required flange thickness will save considerable time. (See author's article in PETROLEUM REFINER, November, 1947.)

$$t = \frac{.604 \times g_1^2 \times n}{\sqrt{B\, g_1}} + \sqrt{\frac{\left(\frac{1.208 \times g_1^2 \times n}{\sqrt{B\, g_1}}\right)^2}{4} + n \times g_1^2}$$

The stresses are,

$$S_H = \frac{M_O}{L \times g_1^2 \times (B + g_1)}$$

$$S_R = \frac{M_O}{L \times t^2 \times B}$$

$$S_T = \frac{M \times Y}{t^2} - Z \times S_R$$

The maximum allowable moment M_O is,

$$M_O = \frac{B \times t^2 \times S_H\,(Z + 1)}{n \times Y}$$

n = stress distribution factor.
(Preferable n = 1.)

Straight Flange Portion

The design bolt load in this portion of the flange causes a rotation therein.

The moment of the couple is,

$$M_G = W_{LIN.IN.} \times a \times h_G$$

in which expression,

a = length of straight portion
h_G = See Figure 2.

This moment must be overcome by the straight flange portion, that is,

$$\frac{M_O}{2} = S_S \times \frac{b_1 \times t_1^2}{6}$$

in which expression,

S_S = Maximum allowable S_R or S_T as calculated for the round portion.
b_1 = See Figure 2.
t_1 = Thickness of the straight flange portion.

Thus, t_1 is,

$$t_1 = \sqrt{\frac{3 \times M_G}{S_S \times b_1}}$$

The proper flange thickness is the larger of the two thicknesses, t_1 or t.

Conclusions

Particular care should be exercised when tightening up the bolts. The overbolting feature penalizes the flange even when there is no internal pressure at all. Calculations are based upon an allowable bolt stress of $S_B = 20{,}000$ psi, when alloy steel bolts are used, and a not too careful tightening up may well cause warping, particularly of the straight flange portion.

SAMPLE CALCULATIONS

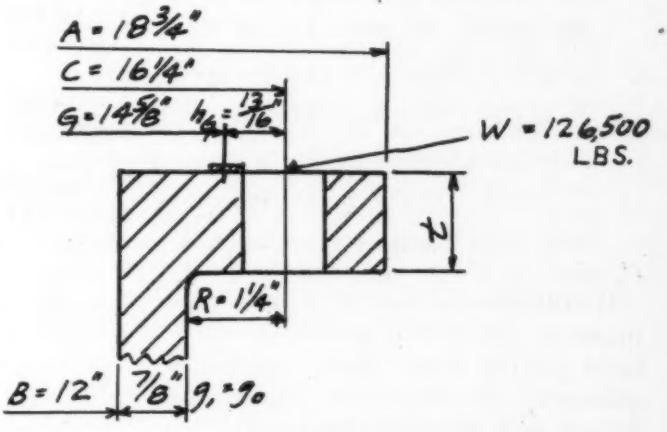


FIGURE 4
Alloy Steel Bolts (½-inch wide steel-jacketed gaskets. No corrosion allowance.)

Round Flange Portion

p = 300 psi
S_B = 20,000 psi
W = 126,500 lbs.

$H_{GY} = \pi \times 14.625 \times .25 \times 8000 = 92{,}000$
$H_{GP} = \pi \times 14.625 \times .5 \times 3.5 \times 300 = 24{,}200$
$H = .785 \times 14.625^2 \times 300 = 50{,}400$

$H_D = .785 \times 12^2 \times 300 = 33{,}900$ $\quad h_D = R + \frac{g_1}{2} = 1.688$ $\quad M_D = 57{,}200$
$H_T = H - H_D = 16{,}500$ $\quad h_T = \frac{1}{2}(R + g_1 + h_G) = 1.468$ $\quad M_T = 24{,}200$
$H_G = W - H = 76{,}100$ $\quad h_G = \frac{1}{2}(C - G) = .813$ $\quad M_G = 61{,}900$
$M_O = 143{,}300$
$S_F = 15{,}000$ psi

K = 1.56 $\quad$ t = 1-9/32-inch $\quad t^2 = 1.64 \quad t^3 = 2.1$
T = 1.69
Z = 2.4 $\quad \alpha = 1.36$
Y = 4.54 $\quad \beta = 1.48$
U = 5.0
h_o = 3.25 $\quad \gamma = .805$
F = .908
V = .551 $\quad \delta = .093$
d = 22.6
e = .28 $\quad L = .898$

$$S_H = \frac{143{,}300}{.898 \times .766 \times 12.875} = 16{,}100$$

$$S_R = \frac{1.48 \times 143{,}300}{.898 \times 1.64 \times 12} = 11{,}900$$

$$S_T = \frac{143{,}300 \times 4.54}{1.64 \times 12} - 2.4 \times 11{,}900 = 4500$$

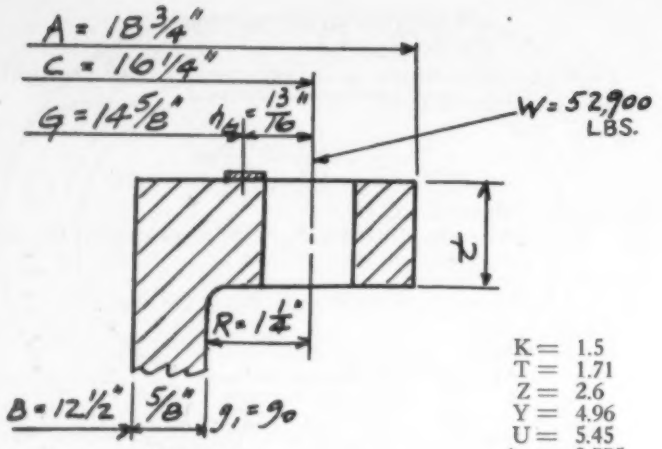


FIGURE 5

Carbon Steel Bolts. (½-inch wide asbestos gasket. ¼-inch corrosion allowance.)

K = 1.5
T = 1.71
Z = 2.6
Y = 4.96
U = 5.45
h_o = 2.775
F = .908
V = .551
d = 11.2
e = .325

SAMPLE CALCULATIONS

Round Flange Portion (See Figure 5)

$H_{GY} = \pi \times 14.625 \times .25 \times 4500 = 51{,}800$ p = 160 psi.
$H_{GP} = \pi \times 14.625 \times .5 \times 2.5 \times 160 = 9{,}200$ S_B = 6,875 psi.
$H = .785 \times 14.625^2 \times 160 = 26{,}900$ W = 52,900 lbs.

$H_D = .785 \times 12.5^2 \times 160 = 19{,}700$ $h_D = 1.563$ $M_D = 31{,}000$
$H_T = H - H_D = 7{,}200$ $h_T = 1.343$ $M_T = 9{,}600$
$H = W - H = 26{,}000$ $h_R = .813$ $M_G = 21{,}000$
$M_o = 61{,}600$

$t = \frac{13''}{16}$ $t^2 = .66$ $t^3 = .536$
$\alpha = 1.265$ $S_H = \frac{61{,}600}{.787 \times .391 \times 13.125} = 15{,}200$ psi.
$\beta = 1.35$
$\gamma = .74$ $S_R = \frac{1.35 \times 61{,}600}{.787 \times .66 \times 12} = 12{,}700$ psi.
$\delta = .047$
$L = .787$ $S_T = \frac{61{,}600 \times 4.96}{.66 \times 12} = 2.6 \times 12{,}700 = 4{,}000$ psi.

Per the given formula, (n = 1.4)

$$t = \frac{.604 \times .875^2 \times 1.4}{3.25} + \sqrt{\frac{\left(\frac{1.208 \times .875^2 \times 1.4}{3.25}\right)^2}{4} + 1.4 \times .766}$$

$t = 1.282$ inch

The individual stresses are calculated above.

Straight Flange Portion

$S_S = 13{,}900$ psi

$M_G = 2750 \times 6 \times .813 = 135{,}000$; $t_1 = \sqrt{\frac{3 \times 135{,}000}{13{,}900 \times 2.5}}$
= 1.08 inches for 12 x 18-inch manhead.

$= 2750 \times 8 \times .813 = 179{,}000$; $t_1 = \sqrt{\frac{3 \times 179{,}000}{13{,}900 \times 2.5}}$
= 1.24 inches for 12 x 20-inch manhead.

$= 2750 \times 12 \times .813 = 268{,}000$; $t_1 = \sqrt{\frac{3 \times 268{,}000}{13{,}900 \times 2.5}}$
= 1.52 inches for 12 x 24-inch manhead.

It will thus be seen that the flange thickness t = 1 9/32 inches as calculated for the round flange portion is governing for the 12 x 18-inch and 12 x 20-inch manhead flanges. For the 12 x 24-inch manhead again the actual flange thickness is t_1 = 1.52 inches as calculated for the straight flange portion.

Per the given formula, (n = 1)

$$t = \frac{.064 \times .625^2}{2.775} + \sqrt{\frac{\left(\frac{1.208 \times .625^2}{2.775}\right)^2}{4} + .391}$$

$t = .773$ inch = approx. $\frac{13}{16}$ inch.

For t = 13/16 inch the individual stresses are as calculated above.

Straight Flange Portion

$S_S = 14{,}800$ psi.

$M_G = 1150 \times 6 \times .813 = 5{,}600$ $t_1 = \sqrt{\frac{3 \times 5{,}600}{14{,}800 \times 2.5}} = .673$ inch.

$= 1150 \times 8 \times .813 = 7{,}450$ $t_1 = \sqrt{\frac{3 \times 7{,}450}{14{,}800 \times 2.5}} = .773$ inch.

$= 1150 \times 12 \times .813 = 10{,}800$ $t_1 = \sqrt{\frac{3 \times 10{,}800}{14{,}800 \times 2.5}} = .933$ inch.

It will thus be seen that the flange thickness t = 13/16 inch as calculated for the round flange portion is governing for the 12 x 18-inch and 12 x 20-inch manhead flanges. For the 12 x 24-inch manhead again the actual flange thickness is t_1 = .933 inch as calculated for the straight flange portion.

* * *

Production and Performance of

DIESEL FUELS

MORE COMPLEX REFINING SEEN AS REQUIRED IF QUALITY OF DIESEL FUEL IS MAINTAINED

J. R. MacGREGOR, G. R. MacPHERSON and P. L. PINOTTI,
California Research Corporation, Richmond, Calif.

DIESEL engine manufacturers frequently specify in detail the quality of diesel fuel to be burned in their engines. In the past some of these specifications have been so restrictive that petroleum refiners have found it desirable and necessary to produce special grades such as automotive and locomotive diesel fuels in addition to their regular grade. Some refiners also produce a bunker grade which may be either a distillate or a residual fuel. The latter is used in many large low speed diesel engines. Since only a small proportion of the diesel engines burn residual fuel, this paper is confined to discussion of the manufacture and performance of distillate diesel fuels.

Crude Oil Sources

Nearly all of the petroleum crude oils in the world are suitable for the production of diesel fuel. There are some like Pennsylvania, East Texas and Mid-Continent from which a high yield of excellent quality fuel may be produced by distillation; there are others such as certain West Texas and California crudes whose distillates require further refining to make the higher ignition quality fuels. On the other hand, there are some petroleum oils such as the highly aromatic crudes found in the East Indies from which essentially no high quality diesel fuel can be produced. However, even from these crudes certain low ignition quality residual fuels are sometimes manufactured. An example is Tarakan crude of Borneo which is about 20° API gravity, 0.2 percent sulfur content, and 33 cetane number. It is used directly without refinement as a black marine diesel fuel.

As long as a substantial amount of crude petroleum is produced there will be distillates suitable for the production of high quality diesel fuels. In almost all regions where crude oil is produced the majority of the newly discovered fields produce oil from the deeper zones. Usually the deeper the zone the older it is in geological age, and generally the older the zone the

***THE COMPETITION** for petroleum distillates boiling in the ranges of 350° to 750° is tremendous. The consumption in 1947 of these gas oil fractions as diesel fuels and heating oils was more than 150 percent of that consumed in 1941. Much of this market growth is due to the installation of additional domestic and industrial heating facilities; however, percentage-wise the diesel fuel consumption increased more than the heating oils. These factors, coupled with the increasing use of virgin gas oil of diesel fuel boiling range as charging stock to catalytic crackers has so intensified the competition for this stock that to meet the demands much cracked oil is, and more soon will be, marketed in furnace oils and diesel fuels. Increased use of cracked stocks as well as less desirable virgin gas oils in diesel fuels introduces additional refining steps which increase the cost of manufacture especially if diesel fuel quality is to be maintained or improved.*

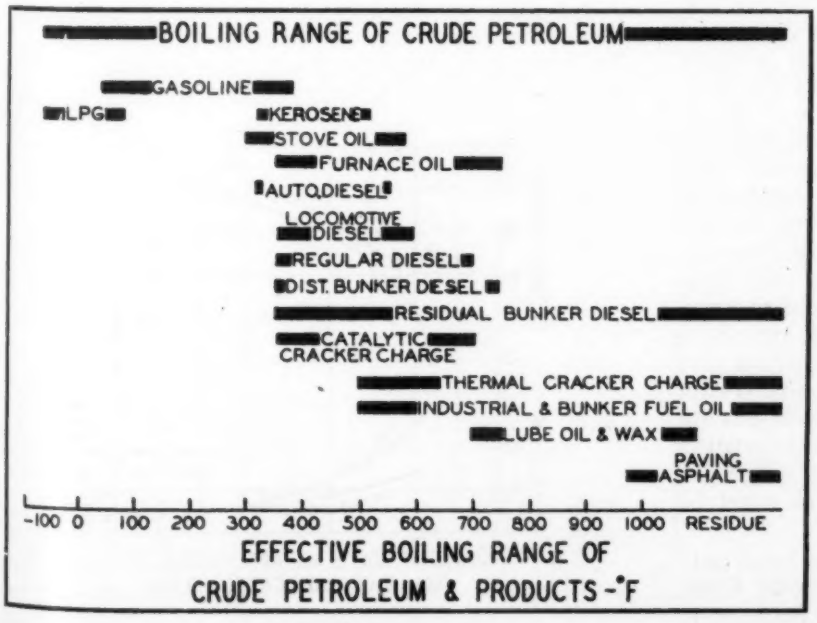


FIGURE 1
Comparison of the Volatility of Crude Petroleum and Products

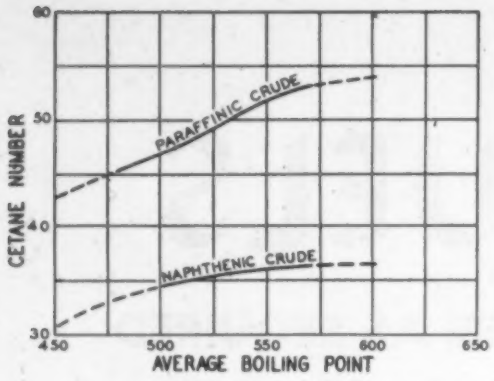


FIGURE 2
Relationship between Volatility and Cetane Number of Two California Straight-Run Gasoils.

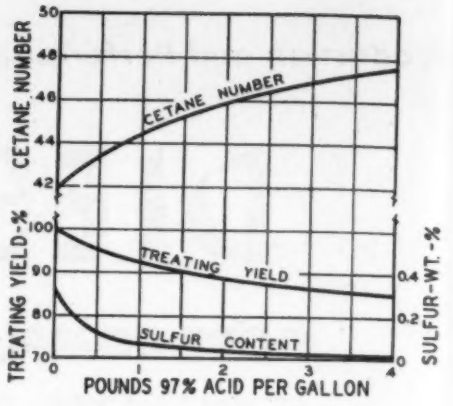


FIGURE 3
Laboratory Acid Treating of a Diesel Fuel from Ventura Avenue Crude.

more paraffinic the crude oil. Gas oils from paraffinic crudes are of high ignition quality and usually of low sulfur content. Exceptions to the latter are gas oils from Middle Eastern crudes which range between 1 and 2 percent sulfur content by weight.

In the event of petroleum shortage, high quality diesel fuels can be obtained from synthetic oils such as those produced by the Fischer-Tropsch process. Shale oil is less suitable as a source of diesel fuel, but it is believed that if it should become necessary to produce large volumes of high quality diesel fuel from shale oil, techniques could be developed that would be commercially feasible. They would, however, be more expensive than those used for the production of diesel fuels from petroleum. For this and other reasons it will probably be many years before a substantial amount of diesel fuel is produced from shale oil.

Vegetable oils have been reported to be suitable substitutes for petroleum diesel fuels, but considerable development work would be required before facilities for large scale production of such fuels could be designed and constructed. It is probable that extensive development work on diesel engines would also be required.

Diesel Fuels from Petroleum

Crude petroleum is a complex mixture of hydrocarbons having effective boiling points from below zero to over 1000° F. It generally contains some nonvolatile residue. The volatility distribution of most crude oils is fairly uniform. Figure 1 shows the boiling range of the more important products produced from petroleum. It is evident by inspection that the competition for the distillates boiling between 350° and 750° F., is great and that it is most serious in the range of 350° to 550° F. Gas oil boiling in this latter range is required in kerosine, stove oil, furnace oil and all of the different grades of diesel fuel. It is also a desirable part of catalytic cracker and thermal cracker charging stocks. In addition some gas oil in this boiling range is generally used in industrial fuel oil in order to insure a satisfactory viscosity. From this it may be seen that as the demand for gas oil fuels, including diesel fuels, grows the competition for petroleum distillates in this boiling range increases and changes in refining procedures must be made.

In the past the diesel fuel consumed has been only a small part of the total demand for gas oils. Until recently most burner and diesel fuels were principally straight run gas oils produced by distillation of crude petroleum. The regular grade of diesel fuel was generally a rebrand of furnace oil or burner oil, and if a higher quality product was required it was produced in small volume from carefully selected crude oil. Currently in order to supply the demand for distillate fuels large volumes of catalytically cracked and thermally cracked gas oils are being marketed, some of which are included in diesel fuels.

In producing high quality diesel fuel many specifications must be satisfied. These include limits on volatility, ignition quality, sulfur content, viscosity and pour point. Frequently, if a gas oil is of high cetane number it is also of high pour point. Hence careful segregation and blending are required to obtain a product of high cetane number with a low pour point. Similarly, as shown in Figure 2, the volatility and cetane number tend to oppose each other. From the point of view of minimum smoke and ease of starting a product of low average boiling point and high cetane number is desirable. Yet for a given crude oil, the lower the average boiling point of the distillate, the lower the cetane number.

The refining of straight run gas oil has generally been limited to one or more of the following inexpensive processes: caustic washing, water washing, and brightening (removal of the last traces of water contained in the gas oil from previous processing). Some grades of diesel fuel require further refinement to meet ignition quality and sulfur specifications. The two processes in general use are concentrated sulfuric acid treatment and selective solvent refinement using liquid sulfur dioxide as the solvent.

Sulfuric acid treatment removes certain hydrocarbon components largely in the form of sludge.

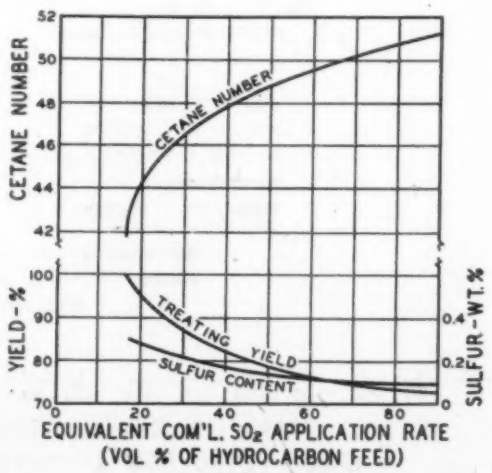


FIGURE 4
Simulated Commercial SO_2 Treating of a Diesel Fuel from Ventura Avenue Crude.

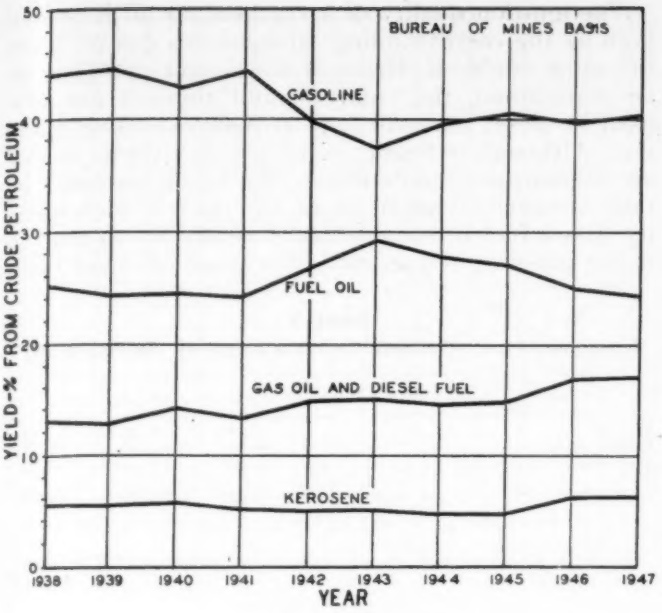


FIGURE 5
Yields of Major Products from Crude Petroleum Refined in the United States.

The treated product is improved by a reduction in sulfur content and an increase in cetane number. This is illustrated in Figure 3 which shows laboratory data obtained on treatment of a gas oil from Ventura Avenue crude (California).

Corresponding results for sulfur dioxide treatment of Ventura Avenue gas oil are shown in Figure 4. Briefly, in this process dry gas oil is counter-currently contacted with liquid sulfur dioxide. The raffinate or refined oil is more paraffinic than the feed to the plant and is of lower sulfur content. The balance or extract, ordinarily about 20 to 30 percent of the feed, is highly aromatic. Its sulfur content is several times that of the feed since the sulfur containing molecules are concentrated in it along with other impurities. It should be emphasized that solvent treatment is a separation process and there is essentially no stock destroyed, whereas in acid treatment there is a substantial destruction of gas oil fractions.

TABLE 1

Five Point Improvement in Centane Number of Diesel Fuel—Economic Comparison of Acid Treating and Solvent Refining of Ventura Avenue Gas Oil

PROCESS USED	Acid Treating	SO_2 Solvent Refining
Gas oil to process, gallons	116	80
Gas oil by-passed to diesel fuel, gallons	....	40
Total 41.8 cetane number gas oil used, gallons	116	120
Acid rate, pounds/gal. treated, (97 percent acid)	3.1	....
SO_2 rate, percent of feed	....	70
Acid treated gas oil	100	
SO_2 Raffinate	....	60
Gas oil by-passed to diesel fuel	....	40
Total 46.8 cetane number diesel fuel made	100	100
SO_2 extract to fuel oil	....	20
Stock lost to sludge	16	....
Stock cost of gas oil used at 10c/gal.[3]	$11.60	$12.00
Processing cost:		
Acid treating at 3.0c/gal. charged[1]	3.50	.....
SO_2 refining at 1c/gal. charged[2]	.....	.80
Total cost	$15.10	$12.80
Value of extract at 8c/gal.[3]	.....	1.60
Cost of 100 gal. 46.8 cetane number diesel fuel	$15.10	$11.20
Cost of 46.8 cetane number diesel fuel, c/gal.	15.1	11.2
Cost of upgrading 5 cetane numbers, c/gal.	5.1	1.2

[1] Acid taken at 0.87c/lb. and labor utilities, other chemicals and amortization of plant investment assumed to be 0.3c/gal. charged.
[2] Assumed for labor, utilities, and chemicals including SO_2 make up the amortization of plant investment.
[3] Oil & Gas Journal, Vol. 46, No. 47, P. 250 (1948).

Stock destruction is a large factor in the economic comparison of acid treating with solvent refining. To illustrate this, processing requirements for production of a diesel fuel of 5 points higher cetane number than the raw gas oil are shown in Table 1. Figures 3 and 4 are used as the basis. Here 100 gallons of the improved diesel fuel is produced by each process. The acid treating process requires treatment of 116 gallons of gas oil with 3.1 pounds of 97 percent sulfuric acid to produce 100 gallons of diesel fuel. A total of 120 gallons of raw gas oil is required for the solvent refining case. Under the conditions assumed, 80 gallons of the distillate is solvent refined producing 60 gallons of raffinate and 20 gallons of extract. The balance of the raw gas oil, 40 gallons, is blended with the 50.2 cetane number raffinate to produce the improved diesel fuel. The 20 gallons of extract is available for use in fuel oil. The cost of improving the cetane number is estimated to be 5.1 cents a gallon by acid treatment and 1.2 cents a gallon by solvent treatment. In either case, the cost is substantial for the 5 cetane number improvement in the diesel fuel.

Manufacturing Trends

After World War I, crude petroleum became scarce in certain parts of the United States and the price increased. At about this time a substantial amount of thermal cracking was introduced in refineries in order to balance operations so that more gasoline and less gas oil and residual fuel would be produced from a barrel of crude oil. This was necessary if the gasoline supply was to be adequate to meet the demand created by the always increasing number of automobiles. During the 30's the yield of gasoline produced from refining of petroleum in the United States increased until it was about 45 percent, as shown in Figure 5. There was not much change in the yield until World War II. During the early part of the war the yield of gasoline was reduced to conserve automobile tires, and later, it was maintained at this level to meet war demands. Since the

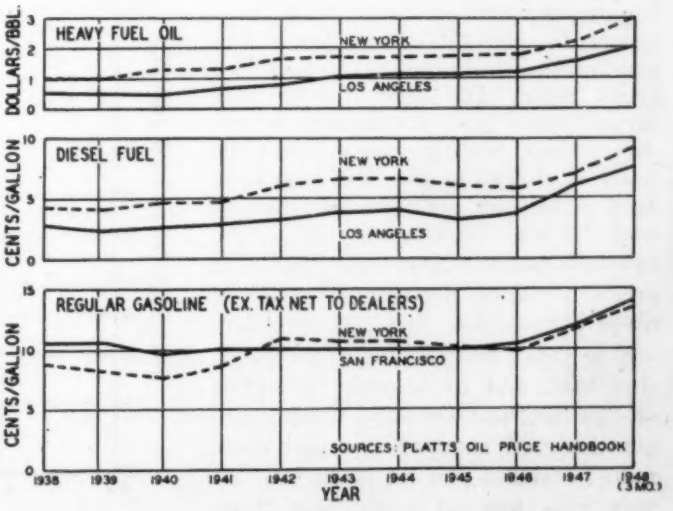


FIGURE 6
Minimum Prices of Selected Petroleum Products

TABLE 2

Domestic Consumption of Middle Distillates (Barrels Daily)

CLASSES OF CONSUMERS	1941	1947[1]	1948[2]
Range oils	126,330	198,900	225,250
Home Heating	331,260	465,430	505,460
Tractor fuels	17,720	37,810	39,980
Railroads:			
Distillate fuels	6,010	6,300	6,280
Diesel fuels	7,540	46,580	55,190
Total	13,550	52,880	61,470
Public utilities:			
Distillate fuels	9,130	14,520	15,030
Diesel fuels	4,980	12,330	13,110
Total	14,110	26,850	28,140
Industrial	31,440	74,520	76,260
Marine equipment	30,020	44,110	44,400
Misc. distillate consumers	75,360	100,000	101,090
Misc. diesel consumers	24,030	69,860	86,800
Total middle distillate	663,820	1,070,360	1,168,850

[1] Partly estimated. [2] Forecast.

Source of table: Knight, E. T., "Review-Forecast", Oil & Gas Journal 46, No. 39, 174-180, (1948).

war the over-all yield of gasoline from crude oil has remained at about 40 percent. During the last ten years the yield of gas oil and diesel fuel has increased from about 13 percent in 1938 to 16.8 percent in 1947, an increase of about 30 percent. The yield of kerosine has increased slightly whereas the yield of fuel oil has decreased. The yield of the balance of the products, including processing loss, has increased slightly.

There are numerous factors responsible for the large increase in demand of distillate fuels. Tables 2 and 3 show that volume-wise the increase is primarily due to heating requirements; however, the increase in diesel fuels, percentage-wise, is much greater. In 1941 about 75,000 barrels of distillate daily was used as diesel fuels whereas in 1947 this had increased to more than 190,000 barrels. Percentage-wise, the 1947 demand for diesel fuels was more than 250 percent of the volume consumed in 1941 and the forecasted demand for 1948 is nearly 300 percent. It might be observed that the advent of compounded diesel engine lubricating oil[1] in the 30's broadened the field of utilization of high speed diesel engines and thereby increased their popularity.

With the modernization of refining facilities more and more catalytic cracking capacity is being installed. These plants are more costly than thermal cracking units; consequently, it is economically desirable to obtain the maximum production of gasoline from them. In order to do this straight run gas oil fractions in the diesel fuel boiling range must be used as charge stock. The next best feed is heavier straight run gas oil and the least desirable is the partly cracked gas oil from the catalytic cracker. Hence, the trend is towards diverting salable straight run gas oils to catalytic cracking. To replace this loss, and to provide sufficient stocks for the increasing market demand, much catalytically and thermally cracked gas oil is finding its way into gas oil sales, and large volumes are being and will be burned as diesel fuels.

The ignition quality of a cracked gas oil is not as high as the corresponding straight run gas oil from the same crude oil. Hence if diesel fuel quality is to be maintained, the catalytic and thermal gas oils used in diesel fuel will both require extensive refining. Although refining processes for these stocks are known, some difficulties may be encountered in their commercial application. The price of high quality diesel fuel in some areas is nearly up to that of motor gasoline and as further refining of diesel fuels becomes necessary this price differential may be further reduced.

TABLE 3

Component Parts of Middle Distillate Demands (Barrels Daily)

	1941	1947[1]	1948[2]
Kerosine	190,330	274,950	296,480
Distillate fuels	398,560	602,260	651,180
Diesel fuels	74,930	193,150	221,200
Total	663,820	1,070,360	1,168,860

[1] Partly estimated. [2] Forecast.

Source of table: Knight, E. T., "Review-Forecast", Oil & Gas Journal 46, No. 39, 174-180, (1948)

Price Trends

Figure 6 shows the price of selected products from petroleum for the years 1938 to 1948 for both the East and West Coast. Many economic factors enter into the price trends, but they all reduce to more and more assessment of the refining cost and profit against the heavier products. We do not see any reversal of this price trend in the near future.

Improvement of Ignition Quality by Additives

For a number of years it has been known that the addition of certain very reactive organic compounds such as amyl and butyl nitrate to a diesel fuel improves its cetane number. Other commercial additives have been developed which approach the nitrate in effectiveness. Figure 7 illustrates the response of a California gas oil to amyl nitrate and to two commercial additives. These data are not strictly comparable to those in figure 4; however, for illustrative purposes 1 percent of commercial additive "B" is

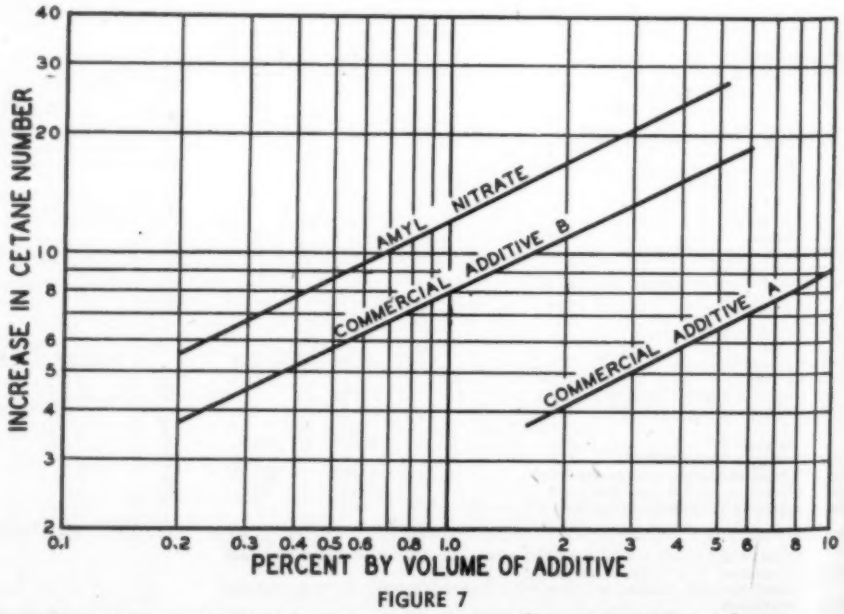


FIGURE 7

Typical Cetane Number Improvement Obtained with Several Diesel Fuel Additives

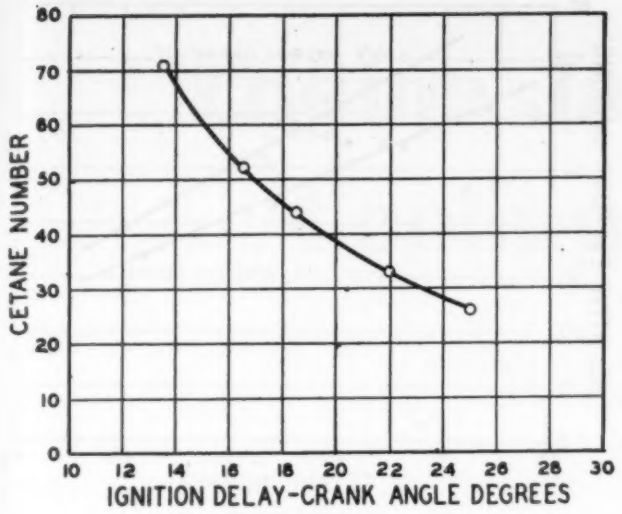


FIGURE 8

Effect of Cetane Number on Ignition Delay. Operating Conditions: rpm, 1350; compression ratio, 15:1; F/A, 0.05; Intake Air Temperature, 150° F.; Injection Timing 25° BTC.

about equivalent to treatment with 70 percent of SO_2. This additive is economically competitive with solvent refining for cetane number improvement.

It is believed that additives have an important place in the future of diesel fuel manufacture.

Engine Performance as Affected by Fuel Characteristics

Diesel engines as manufactured today are of two basic designs; namely, four cycle and two cycle engines. Additional features, such as combustion chamber design, size and speed, affect the basic fuel requirements of the engine. In addition to these, the performance of the diesel engine is affected by several other factors: 1) Mechanical condition of the engine; 2) Method of operation; and 3) Type of fuel consumed. The following discussion will be limited to item three.

When high speed and railroad diesel engines were introduced to the public, manufacturers issued restrictive specifications for fuels to be used. The refiner was therefore frequently faced with the necessity of producing special fuels to meet these requirements. In many cases, subsequent service experience has demonstrated that fuels meeting more liberal specifications worked satisfactorily. As a result some engine manufacturers have relaxed their requirements on cetane number, volatility, and sulfur content but maintained requirements which will insure the consumer a clean fuel. From the refiners' standpoint, when special quality requirements are specified, additional processing or stock selection is required which is generally reflected in higher prices to the consumer. It is, therefore, to the interest of the engine user to make certain that he is not demanding a higher quality fuel than is necessary if he wishes to maintain the substantial economic advantage of the diesel engine over that of the other prime movers.

Cetane number or some related measure of ignition characteristics has been used as an index of diesel fuel quality by engine operators since the advent of the automotive diesel engine. The operators have been justified in this practice because the cetane number of the fuel influences ease of starting, combustion roughness, and exhaust smoking. The degree to which performance is affected by cetane number varies with different engines.

Although the subject of cetane number is sometimes presented in a manner that makes it seem like a very complex unit, actually it is nothing but an index system indicating the time the fuel starts to burn after it leaves the nozzle. The higher the cetane number of the fuel the shorter is the interval between injection and the start of combustion. This is illustrated in Figure 8 where it may be noted that in a laboratory test engine a 26 cetane fuel had a delay approximately 11 crank angle degrees longer than a 71 cetane fuel. The effect of cetane number on peak cylinder pressures and engine roughness in the same engine is shown in Figures 9 and 10. The importance of cetane number in these instances is evident.

The laboratory test engine from which the data of Figures 8, 9 and 10 were obtained did not produce objectionable exhaust smoke under any of the normal operating conditions investigated. However, as an example of the influence of cetane number in an engine that presents an exhaust smoke problem, Figure 11 is of interest. It will be noted that although a reduction in smoke was obtained with the higher cetane fuels, it was not eliminated by this means.

The cetane number of the fuel also affects the ease with which an engine may be started. While increasing the cetane number tends to minimize starting difficulties at low temperature, the influence is of a limited nature. Fortunately, satisfactory starting aids are available.

The sulfur content of diesel fuel has been shown in the laboratory under carefully controlled conditions to affect engine deposition and wear adversely. This has been reported by several investigators[2, 3, 4].

The field data from certain types of engines substantiate the laboratory results directionally. However, the absolute values for wear and deposition vary widely between different engines. The effect of sulfur in diesel fuels may be masked by such operating variables as maintenance practices, engine operating conditions, and impurities which may enter the intake manifold. It is possible that any adverse effect sulfur may have from a wear standpoint can be minimized through technological advancements in the composition of engine liners and rings, better control of engine operating temperatures, and improvement in lubricating oil quality. This would be desirable from the fuel manufacturer's standpoint.

Limits on viscosity, volatility, and pour point of a diesel fuel are included in most specifications. The limits on viscosity are necessary to insure a diesel

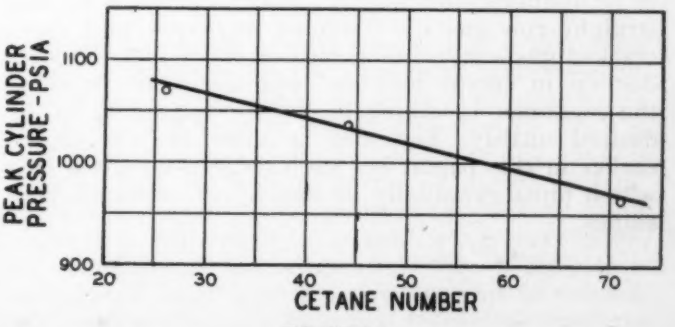


FIGURE 9

Effect of Cetane Number on Peak Cylinder Pressure. Operating Conditions: rpm, 1350; Compression Ratio, 15:1; F/A, 0.05; Intake Air Temperature, 150° F.; Injection Timing, 25° BTC.

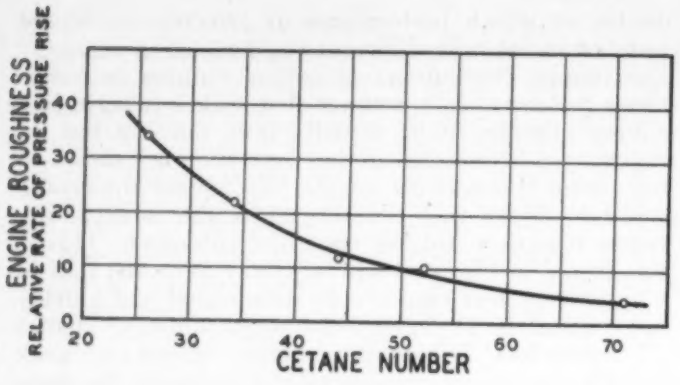


FIGURE 10

Effect of Cetane Number on Engine Roughness. Operating Conditions: rpm, 1350; Compression Ratio, 15:1; F/A, 0.05; Intake Air Temperature, 150° F.; Injection Timing, 25° BTC.

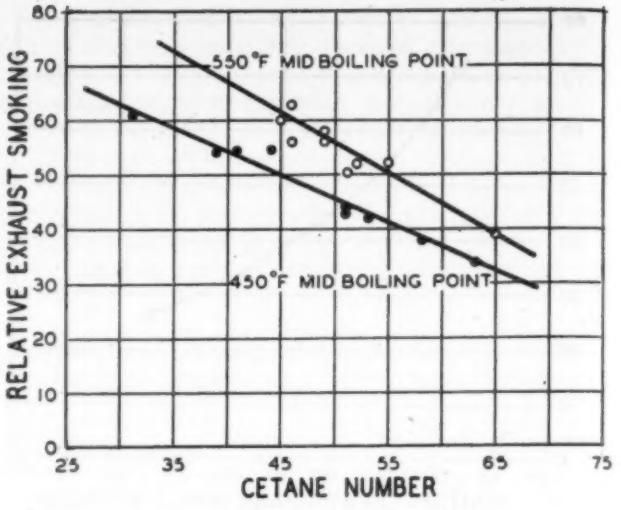


FIGURE 11

Relation between Cetane Number and Exhaust Smoking with Fuels of 450 and 550 Mid-Boiling Points. Operating Conditions: rpm, 1800; Horsepower, 140; Compression Ratio, 17:1.

fuel that will give satisfactory penetration and atomization and also provide necessary lubrication to those parts of the injection system that rely on the fuel for lubrication. Volatility influences the ease with which the liquid fuel can be converted to a combustible state. One result of an incomplete conversion on combustion is exhaust smoke. Figure 11 illustrates the effect of a 100° F. change in mid-boiling point on the exhaust smoke of one type of engine.

The pour point of a diesel fuel is critical in cold weather operation. Unless means for heating the fuel are provided, the pour point and viscosity must both be low enough to permit fuel transfer and insure adequate flow of fuel to the engine under the prevailing ambient temperature conditions. A reduction of the pour point of a diesel fuel through the use of pour point depressants has so far proven impractical, and further refining to improve this property involves prohibitive costs. It is therefore frequently necessary, where very low ambient temperatures are expected, to waive cetane number and minimum viscosity limits in order to obtain fuels with suitable pour point characteristics.

Future Cetane Number and Sulfur Content Specifications

In the past the cetane number and sulfur content of diesel fuel have largely been determined by the selection of the crude oil used for diesel fuel manufacture. Since World War II the general practice on the Pacific Coast has been to maintain these diesel fuel properties at about the same level as prewar. (This may not be true for other parts of the United States). In the future the cetane number will tend to be reduced somewhat as the competition for the straight run gas oil fractions increases, and more cracked gas oils are marketed in diesel fuel. This reduction in cetane number need not occur provided the consumer is willing to pay for upgrading to the desired quality. This can be done as was shown earlier in this paper, but each method entails a cost which must eventually be met by the ultimate consumer.

The average sulfur content of diesel fuels will remain near the current level. However, it may increase in certain sections of the United States due to the importation of high-sulfur foreign crudes or products produced from them. It will also increase in those cases where black Rocky Mountain crudes are used to supplement Mid-Continent crudes for diesel fuel manufacture. In the West it will probably decline slightly due to increased production of the more paraffinic crudes and to the use of more thermal and catalytically cracked gas oils which are lower in sulfur content than the corresponding virgin gas oils from the same crudes. Importations, however, may affect Western production adversely. In much of Texas little change is expected.

In conclusion it is clear that the presently established trends of gas oil consumption are presenting new problems to the petroleum refiner, the diesel engine builder, and the engine operator. If the quality of diesel fuels is to be maintained or improved, additional refining will be required with its attendant increase in cost and ultimate economic effect on the diesel engine user. It will therefore be to the best interests of all diesel engine manufacturers to review the full requirements of their engines and to adopt all possible mechanical aids so that lower quality diesel fuels can be burned satisfactorily.

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NOTE

This paper was presented at the 1948 summer meeting of the Society of Automotive Engineers, French Lick Springs, Ind.

* * *

Engine Jacket Water Cooling Systems

F. L. KALLAM
President, Industrial Engineers, Inc.
Los Angeles, Calif.

DESPITE THE important role played in process plant operations by the jacket cooling systems of internal combustion engines, there has been little semblance of agreement between designers as to the most satisfactory ranges for operating conditions or as to the nature of cooling system equipment suitable for specific applications.

In this detailed report, information gained in a comprehensive survey of a large number of natural gasoline and other hydrocarbon processing plants is subjected to critical analysis by the author. The over-all result is that principal considerations affecting the satisfactory performance of jacket cooling systems are clearly defined. Some of the suggestions made here have high potential value to the designers and operators of such systems.

THE importance of the cooling system employed in connection with the internal combustion engine is well illustrated from the fact that even in a small automobile engine the amount of heat so dissipated and lost is enough to heat a six-room house on a very cold day. Although here the chief concern is the cooling of the larger units employing spark ignition and operating on gas fuel, as utilized in the natural gasoline and cycling industries, the principles developed should likewise be applicable to all types of internal combustion engines.

The magnitude of the cooling problem is readily apparent from Table 1 which shows average figures for spark ignition engine heat balances:

TABLE 1

Heat transformed into shaft work, percent	20-28
Heat carried way by the cooling system, percent	35-32
Heat carried away by the exhaust gases, percent	37-30
Heat not accounted for (radiation, friction, etc.) percent	8-10
	100

Obviously, the rate of heat flow from the burning fuel into the metal cylinder walls far exceeds the capacity of the surrounding air to remove it, and consequently, the metal surfaces become excessively hot. To keep the metal temperatures at a point where trouble-free operation can be maintained, it is customary to place a water jacket around the cylinder and to cause a steady flow of water through this chamber. The water absorbs heat in its passage through the jacket and generally leaves at a temperature above that of its entrance.

If all engines were operated within reach of a large supply of water, the cooling system would be somewhat less complicated. In this case, water would be pumped from the source through the jackets and then either wasted or returned to the source. In the great majority of cases, no such satisfactory supply exists, and the water has to be reused. This requires that the heat put into the water must be dissipated by some means before it can be returned to the engine.

In arriving at the requirements of a cooling system the first step involves figuring how much heat must be removed by the jacket water. The percentage of total heat input to an engine which finds its way into the cooling water varies somewhat for different makes, sizes, and types of engines. In most cases, the manufacturer will give a figure that can be relied upon. Such data is usually furnished as so many Btu's per horsepower per hour at full load. If the jacket water is also used to cool the exhaust manifold, the lubricating oil and compressor jackets, these quantities of heat will also have to be considered. These values can likewise be obtained from the engine manufacturer and their summation will give the total heat load to be removed by the jacket water cooling system.

By way of illustration, Table 2 presents these values as obtained from a manufacturer for one model of 2-cycle engine in two sizes:

TABLE 2

Horsepower of engine	300	400
Heat release from engine jackets B.t.u./Hp/Hr.	3700	3250
Heat release from exhaust manifold, B.t.u./Hp/Hr.	500	500
Heat release from lubricating oil, B.t.u./Hp/Hr.	550	550
Heat release from compressor jackets, B.t.u./Hp/Hr.	550	650
	5600	5350

Water Needs

The second step in the design of the jacket water system is to determine the amount of water needed. By definition, one pound of water will absorb one Btu if the temperature rise is 1° F., or 10 Btu's if the temperature rise is 10° F. Therefore, the amount of water required depends upon the rise of its temperature in passing through the engine. Permitting a large rise will result in a small water circulation, and contrarily, if the temperature rise is held to a low value, a large quantity of water will be needed. It is important to note here that the actual temperature of the water entering the jackets is not considered. Once the amount of heat to be removed is known, the correct water flow follows when the tem-

perature rise is fixed. If the latter is to be 10° F., the water rate will be the same regardless of whether the water enters the jackets at 70° F. or at 170° F. For all practical operating conditions the temperature of the water entering the engine bears no relation to the increase in temperature of the water passing through the engine.

In recent years, particularly since oil cooling has become common in most engine designs, the manufacturer has been willing to recommend, and in some cases, specifies, the temperature rise for the jacket water. But as is the case of all manufacturers, he does not have control of the operation of his equipment and has no assurance that it will be operated as directed. This is true in the case of the cooling system, which the engine builder generally does not furnish, thereby leaving the operator a wide choice of both temperature rise and temperature.

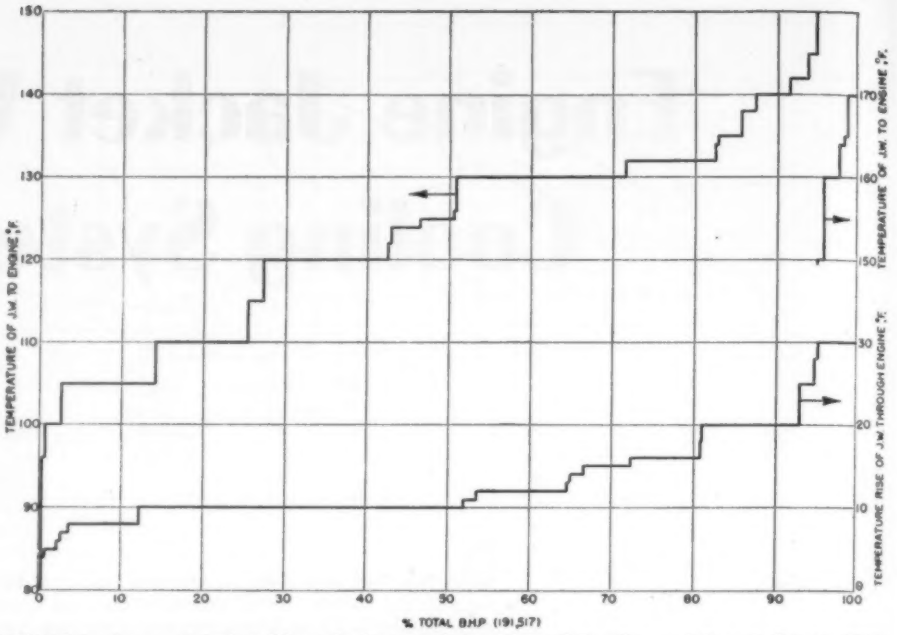


FIGURE 1—Survey of Jacket Water Cooling Facilities, Natural Gasoline and Recycle Plants, 1947. Type of J. W. Cooling—Closed Coils in Cooling Tower.

This wide variance in the selection of temperature rise and temperature in cooling systems is readily apparent from a survey of the literature of the subject and becomes amusing after noting certain actual plant operations. The entire subject is similar to the weather, about which everyone talks, but about which nothing is ever done. For this reason, a survey of existing cooling systems in the natural gasoline and recycle industries was made and is presented here for the first time to show what actually is taking place. It permits a comparison of any one operation with the average for the entire industry, but in doing so, it must be recognized that these averages are not necessarily the optimum operating condition.

In making this survey of the cooling water systems now in operation in the natural gasoline and recycle industries, a simple questionnaire was sent to 429 plants with replies being obtained from 106. The survey is thus based on data obtained from slightly under 25 percent of the plants operating last year. Although this percentage is disappointing, particularly if it indicates lack of interest on the part of the industry, nevertheless, the data does represent the operation of 1485 engine units or a total rated engine brake horsepower of 430,000. The data submitted does not include small multi-cyclinder engines used for auxiliary drives in the plants. Further, in compiling the data, where a single plant reported more than one type of jacket water cooling, the engines on each system have been considered as a separate plant. On this basis, the total number of plants reporting becomes 135 instead of 106.

Five Classifications

In presenting the results of this survey, the cooling systems have been broken down into five general classifications as follows:

1) *Closed Coils In Cooling Towers*—The use of pipe coils or the conventional atmospheric type cooling section through which the jacket water flows, with the spray water from the tower showered over the exterior surfaces.

2) *Open Cooling Towers*—The use of the cooling tower spray water directly through the engine jackets. In this case, the water is pumped from the tower basin through the jackets and then over the top of the tower where the heat is dissipated to the air as the water falls again into the basin.

3) *Air Cooled Radiators*—The case where the jacket water flows through a conventional radiator or finned-tube section with the heat dissipated directly to air which is forced across the exterior tube surfaces.

4) *Closed Heat Exchangers*—The use of the conventional closed type of heat exchanger where the jacket water flows on one side of the heat transfer surface and the cooling medium on the other side. The cooling medium is generally water, although it may be other fluids such as oil or gas.

5) *Waste or Process*—This is a once-through system where the jacket water, after leaving the engine, is wasted and not used again, or where it is used in some other process or for some other purpose than engine cooling.

An inspection of the data covering these five systems of cooling engine jacket water revealed the difficulty of putting it in a form convenient for ready study and interpretation. It was finally decided to base each of the five systems upon the engine brake horsepower operating on each system rather than to consider it from the standpoint of plants using these systems. This followed from the fact that many plants reported the use of more than two of the specified systems in cooling their engines. Likewise, it was felt that the total rated engine brake horsepower would have more significance than grouping the various cooling systems against the number of units or engines using such systems. And finally, a graphical presentation was decided upon as offering a somewhat better means of showing the variations in existing jacket water cooling installations relative to temperature rise and water temperature to the engines.

The results therefore of the survey pertaining to the system of cooling jacket water by means of closed coils in a cooling tower are graphically shown in Figure 1. Here the temperature rise through the

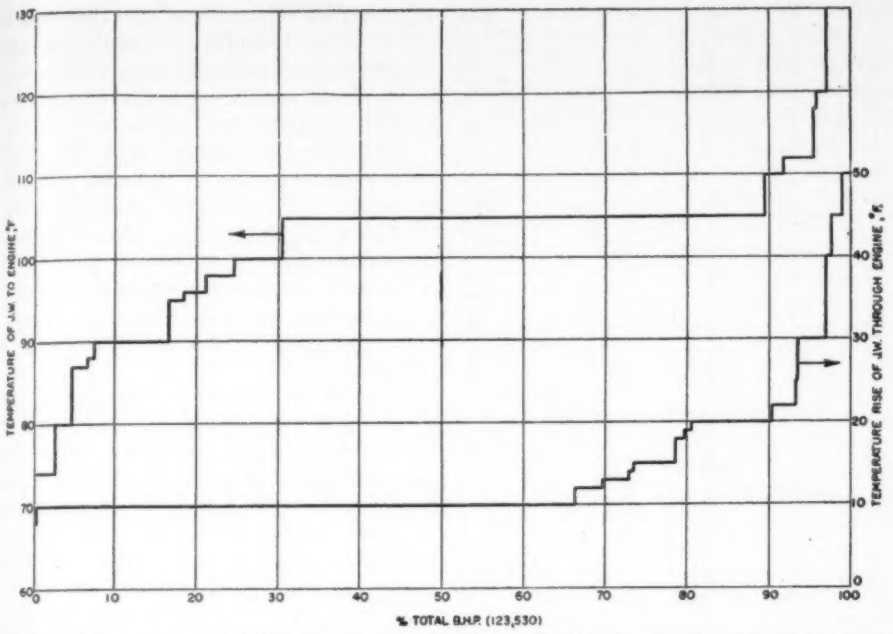


FIGURE 2—Survey of Jacket Water Cooling Facilities, Natural Gasoline and Recycle Plants, 1947. Type of J. W. Cooling—Open Cooling Tower.

engine is plotted on the right hand ordinate against the percent of total bhp. employing this type of cooling as the abscissae. It will be noted from this curve that the temperature rise varies from a low of 4° F. to a maximum of 30° F., which is a surprisingly large spread. The curve lends itself to determining the percentage of total engine rated brake horsepower operating with any temperature rise between these two values. For example, consider a temperature rise of 10° F. The percentages as obtained from the bottom abscissae corresponding to 10° F. rise are 52 and 12. Subtracting these two figures gives 40, which shows that 40 percent of the engine bhp. reported operate with a 10° F rise in jacket water temperature. Now consider the highest temperature reported, or 30° F. The percentage of the total engine bhp. operating with this rise is 100 —95, or 5 percent. The curve also shows that 100 —52, or 48 percent of the engine bhp. is operated with a temperature rise through the jackets in excess of 10° F.

On the left-hand ordinate of Figure 1 is plotted the actual temperature of the jacket water to the engines. This temperature varies from a low of 80° F. to a high of 170° F. Again this is a wide variation which is also surprising. An inspection of this curve for 130° F. temperature jacket water shows that (71.5 —51) 20.5 percent of the total reported engine bhp. using closed coils for cooling operate at this temperature. It also shows that 51 percent of the total engine bhp. operate with an inlet jacket water temperature below 130° F.

The data reported for those cases employing the open type of jacket water cooling have been similarly plotted in Figure 2. The desired operating information can be obtained from them in the same manner as described for Figure 1.

Likewise, the data for the air-cooled radiator type of cooling will be found plotted in Figure 3.

The data for those cases employing closed heat exchangers for jacket water cooling are plotted in a similar manner and shown by Figure 4.

The last of the plants reporting wasting the jacket water or using it in other processes will be found shown by Figure 5.

A vast amount of information is provided by these five curves, and a detailed study of them will result in a clear and correct picture of engine cooling practices during 1947. For those not interested to this extent, a brief resume of their data has been prepared in tabular form and appears in Table 3.

The American Society of Mechanical Engineers recently published its latest, "Report on Oil-Engine Power Cost for 1945," which is the twelfth issue since 1934 covering stationary generating plant operating practices. This fact-finding report made it possible to obtain additional information on the cooling of oil engines as operated in another industry, and the data so developed are presented in Table 4. By slightly rearranging the data from this present survey, as set forth in Table 3, and inserting it in Table 4, it has been possible to present a comparison between the cooling practices of the two industries. It is felt that this additional information will add to the usefulness of this present work.

So far the data presented have been factual and no attempt has been made to interpret the facts or to establish conclusions. It is now in order to make such an attempt.

Although our paramount interest is in the actual temperature rise and temperature of the water passing

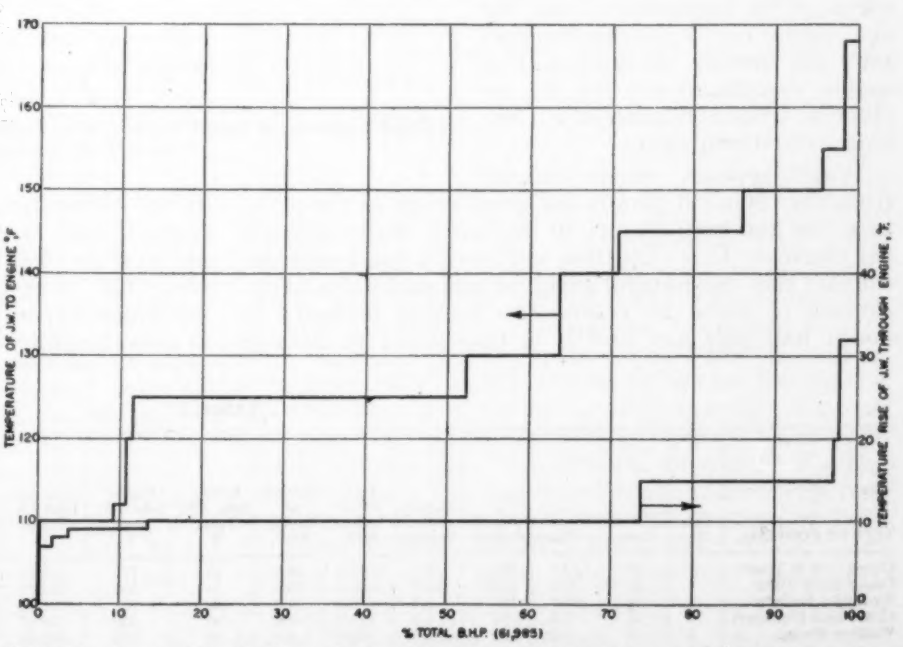


FIGURE 3—Survey of Jacket Water Cooling Facilities, Natural Gasoline and Recycle Plants, 1947. Type of J. W. Cooling—Air-Cooling Radiators.

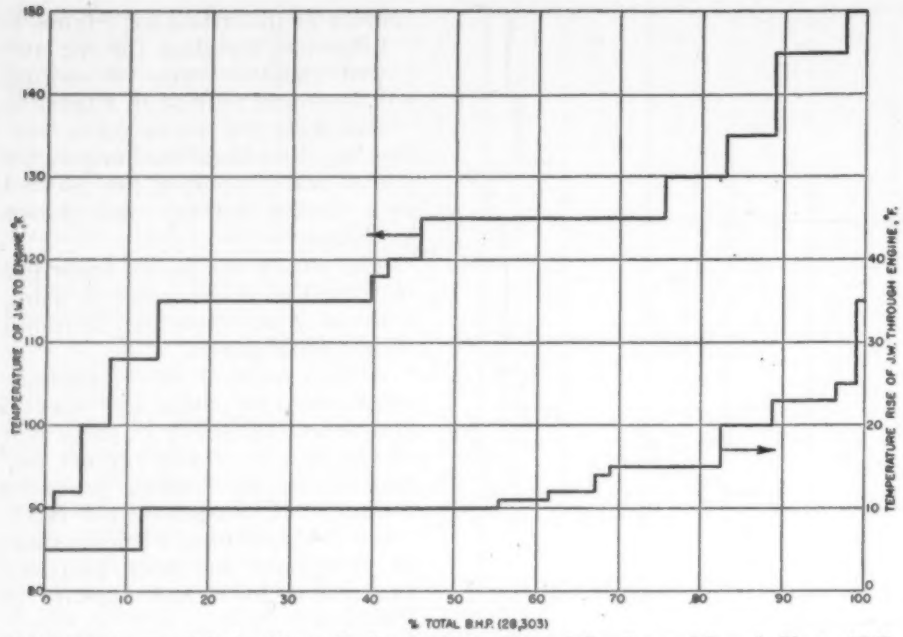


FIGURE 4—Survey of Jacket Water Cooling Facilities, Natural Gasoline and Recycle Plants, 1947. Type of J. W. Cooling—Closed Heat Exchangers.

that its equipment on the whole is more modern. Complications developed when it was attempted to treat each separately and for this reason no segregation was possible although, had it been accomplished it would doubtlessly have proved enlightening. Generally speaking, where operating practice is found to vary over a wide range as is the case here, it is safe to conclude that fundamental principles are not too well understood.

The averaging of the reported data very definitely shows that those engines equipped with the open type of jacket water cooling system operate with the lowest inlet water temperatures. In the early days of the industry this type of cooling was almost universal and it was found advisable to keep the engine jacket temperature low to avoid severe scale formation. The formation of scale through the engines, it does not seem possible to divorce the method used in cooling this water from the problem. It is suspected that in numerous cases the cooling method is responsible for the actual water conditions reported for the engines. Such a state is in the category of placing the cart before the horse.

It should also be remembered that the plants reporting are not all modern and that many have operated for as long a period as twenty years or even longer. Also, in many instances the cooling equipment may be of fairly recent design and in others the engines may constitute the modern equipment. It is regrettable that the age factor could not be brought into the survey without adding undue complications, for its inclusion would doubtlessly have had a clarifying effect.

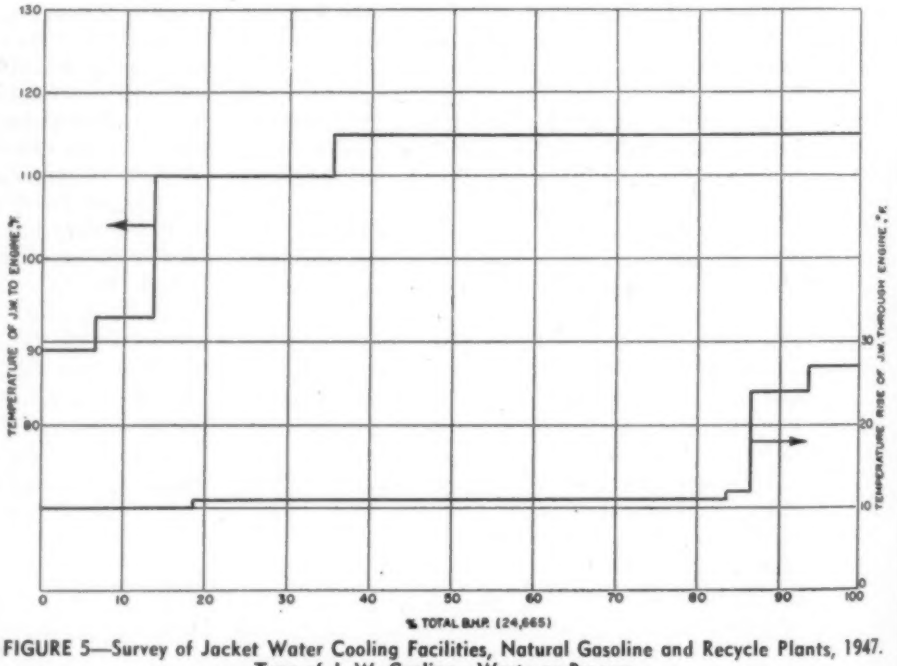


FIGURE 5—Survey of Jacket Water Cooling Facilities, Natural Gasoline and Recycle Plants, 1947. Type of J. W. Cooling—Waste or Process.

What appears most striking from the reported data is the great range of temperature rise and temperature of the jacket water passing the engines. This condition apparently exists despite the fact that the natural gasoline industry has a background of some 25 years. The recycle industry is about half this age and it is reasonable to believe at the higher temperatures probably influenced early engine builders to advocate a maximum leaving temperature of 120° F. in order to reduce their own troubles. The average reported leaving temperature as determined from this survey is 117.5° F. From this it is easy to understand why the impression prevailed

TABLE 3

TYPE OF COOLING	Fig. No.	No. of Plants	Percent of Plants	No. of Engines	Percent of Engines	Total Rated Engine BHP.	Percent of Engine BHP.	Lowest Inlet JW. Temp. °F.	Highest Inlet JW. Temp. °F.	Average Inlet JW. Temp. °F.	Average Outlet JW. Temp. °F.	Lowest Temp. Rise, °F.	Highest Temp. Rise, °F.	Average Temp. Rise, °F.	Percent BHP. Operating with 10 °F. JW. Rise	Percent BHP. Operating with 135-145 °F. Inlet JW.
Closed Coils in Tower..	1	46	34.0	560	37.8	191517	44.5	80	170	126.13	139.94	4	30	13.81	39.7	9.4
Open Cooling Tower...	2	53	39.3	628.5	42.3	123530	28.7	74	130	102.75	117.50	8	50	14.75	65.8	0.0
Air-Cooled Radiator....	3	21	15.6	139	9.4	61985	14.4	100	168	132.71	145.25	7	32	12.54	60.1	22.2
Closed Heat Exchanger.	4	13	9.6	97	6.5	28303	6.6	90	150	120.68	135.31	5	35	14.63	43.5	8.5
Waste or Process.....	5	2	1.5	60	4.0	24665	5.8	90	115	104.50	120.16	10	27	15.66	18.6	0.0
		135	100.0	1,484.5	100.0	439000	100.0									

TABLE 4

TYPE OF COOLING		Nat. Gasoline & Recycle Industries Survey 1947	ASME Oil-Engine Report 1945
Closed Coil and Heat Exchangers	No. of Plants	59	39
	No. of Units	657	130
	Total Rated BHP	219820	108195
	Av. Temp. JW to Engine	124.94	110.46
	Av. Temp. JW From Engine	138.93	125.15
	Av. Temp. Rise of JW through Engine	13.99	14.69
Open Cooling Tower	No. of Plants	53	34
	No. of Units	628.5	99
	Total Rated BHP	123530	72820
	Av. Temp. JW to Engine	102.75	96.79
	Av. Temp. JW from Engine	117.50	117.79
	Av. Temp. Rise of JW through Engine	14.75	21.00
Air-Cooled Radiator	No. of Plants	21	4
	No. of Units	139	13
	Total Rated BHP	61985	4307
	Av. Temp. JW to Engine	132.71	139.00
	Av. Temp. JW from Engine	145.25	148.25
	Av. Temp. Rise of JW through Engine	12.54	9.25
Waste or Process	No. of Plants	2	9
	No. of Units	60	30
	Total Rated BHP	24665	25690
	Av. Temp. JW to Engine	104.50	68.44
	Av. Temp. JW from Engine	120.16	101.11
	Av. Temp. Rise of JW through Engine	15.66	32.67

that engines could only be operated in this low range. But what is still more surprising, in view of this concept, is that the average rise in temperature of the water through the engines is 14.7° F., the highest of all the systems except in the few cases where the water was wasted or used in process. The data also reveals that 28.7 percent of the total engine brake horsepower reported still employ the open system, making it second in prominence today. The scale and other operating troubles resulting from the use of the open system evolved the closed system and the former has gradually over the years fallen into general disfavor. The fact that a great number of plants still employ it is a result of its initial acceptance and the fact that the conventional plant has a rather long life. It is reasonable to believe that future surveys will show a tremendous shrinkage in the brake horsepower operated with open type cooling.

Favorite Method Described

The favorite method of engine cooling, as determined from this survey is the use of closed coils located in the cooling tower and this system is used with 44.5 percent of the total engine bhp reported. With this system the average inlet jacket water temperature is 126.1° F. with a low minimum of 80° F. and a maximum of 170° F. The latter is the highest reported for any system. The average outlet temperature is 139.9° F. with a minimum rise in temperature through the engine of 4° F., and a maximum of 30° F. and an average of 13.8° F. The advent of this system removed the limitations placed on the engine by the open system and led to a cautious increase in temperature over the years. With the closed system, softened or scale free water was used on the jacket side and what scaling took place occurred on the spray water side and did not affect engine operation. As a result, it was not long before engine builders began recommending a maximum of 140° F. for the temperature of the water leaving the jackets. It is believed that where conditions dictate that the jacket water be cooled with spray water that this system will continue to dominate.

A variation in the above system has been the use of the conventional closed type of heat exchanger with the jacket water usually found in the shell side and the spray water passed through the tubes. The closed heat exchanger system has not gained wide acceptance and its use is restricted to 6.6 percent of the engine bhp. The survey data show a reported low inlet temperature of 90° F., a maximum of 150° F. and an average temperature of 120.6° F. for the water to the engine jackets. The average outlet jacket temperature is 135.3° F. The lowest temperature rise through the engine reported is 5° F., the highest 35° F., with an average of 14.6° F. All of these values compare favorably with the corresponding values obtained where employing closed coils in the cooling tower. Probably the reason that the closed heat exchanger has not received wider acceptance is the fact that scale formed on the spray water side necessitates the equipment be placed out of service in order to remove the scale. With the closed coil type this cleaning operation can be accomplished with less down-time and apparently with less expense. Under present conditions, it is reasonable to expect that the closed coil type will continue to dominate over the conventional heat exchanger.

The once-through type of cooling system, where the jacket water is either wasted or used for other process work after it has passed through the engine, has made little headway in the natural gasoline and recycle industries. Only two plants reported its use which represents 1.5 percent of the total number of plants reporting. Actually, the system was used by 5.8 percent of the total engine bhp which closely approaches a value of 6.6 percent for the closed type of heat exchanger cooling. The temperature of the water to the engines, as reported, gives a low of 90° F., a maximum of 115° F. and an average of 104.5° F. The average temperature of the leaving jacket water was 120.1° F. The minimum temperature rise through the engines was 10° F., the maximum 27° F. and the average, 15.6° F. The possibilities of this system of cooling gaining headway appears not too good, chiefly because of the usual shortage of water supply, and the fact that the use of heated water in auxiliary processes within the industry are limited. So despite the fact that this system very definitely increases the overall thermal efficiency of the engines, it is not expected to be used to any great extent unless a demand for low pressure steam or similar use can be developed.

The infant of all the cooling systems as exemplified by the air-cooled radiator or similar equipment, has made the greatest advance in recent years. Despite that its use in the natural gasoline and recycle industries dates back only ten years, it is used in 15.6 percent of the total plants reporting. This represents a use on 14.4 percent of the total engine bhp, a figure which can be considered ultra-conservative. Reports on water to the engines from this system show a low of 100° F., a maximum of 168° F., and an average of 132.7° F., all of these values are the highest reported for any of the five cooling systems. Engines operating with air-cooled equipment show an average outlet jacket water temperature of 145.2° F. The lowest temperature rise through the jackets reported is 7° F., the highest 32° F., with an average of 12.5° F. These figures definitely show that this type of cooling equipment is not being operated under optimum conditions since its efficiency greatly increases as the temperatures are raised. With the acceptance this system has received, as indicated by this survey,

it is obvious that eventually it will be predominating in the natural gasoline and recycle industries.

Slow Evolution Apparent

It is apparent that there has been a slow evolution from low temperature engine jacket operation brought about chiefly by developments in the methods of cooling. Engine builders are today specifying a 10° F. rise in temperature through the jackets with inlet temperatures in the range of 135-145° F. One manufacturer specified 135-150° F. They do this because they know they will not have undue mechanical troubles and that their equipment will prove more satisfactory to the purchaser. It is interesting to accept the above recommendations and apply the data of this survey in order to observe to what degree the combinations of engines and cooling system fall into this category. Assuming a 10° F. rise in jacket water passing through the engines, we first observe the percentage of the reported engine bhp for the various cooling systems now meeting this requirement. The results are set forth in Table 5.

TABLE 5

TYPE OF COOLING	Percent BHP Operating with 10° F. J.W. Rise
Closed Coils in Tower	39.7
Open Cooling Tower	65.8
Air Cooled Radiator	60.1
Closed Heat Exchanger	43.5
Waste or Process	18.6

Very obviously, to meet this 10° F. requirement, all of the systems are operated with too great a temperature rise through the engines in conformity with the latest accepted best practice.

Assuming an inlet cooling water temperature to the engines in the range of 135-145° F., a check was made to see just what percentage of the reported engine bhp for each cooling system is now meeting this requirement. The results are presented in Table 6.

TABLE 6

TYPE OF COOLING	Percent Engine BHP Operating With 135-245° F. Inlet JW.
Closed Coils in Tower	9.4
Open Cooling Tower	0.0
Air Cooled Radiator	22.2
Closed Heat Exchanger	8.5
Waste or Process	0.0

With the exception of the open cooling tower system which can be considered inadequate to operate in the recommended temperature range, it is apparent that the remaining four systems are not operated according to the latest best accepted practice.

An inspection of Table 4, which gives average comparative operating statistics for both the natural gasoline-recycle industry and the oil-engine stationary generating industry, will now prove interesting. In all instances, other than where cooling is provided by the air-radiator type of equipment, the oil-engines are operated at lower jacket water inlet temperatures than the natural gas fuel engines reported in this survey. In the case of radiator cooling, the oil-engine units provide a higher inlet temperature by approximately 8° F., or 139.0° F.

The oil-engines are also operated with greater temperature rises through their jackets than is the case for the gas fuel engines with again the lone exception of where radiator cooling is employed. In this case the average rise in temperature for the oil engines is 9.25° F. and 12.5° F. for the gas engines. In passing, it should be noted that the oil engines with radiator-type coolers fall into what has been termed the latest best accepted operating practice. This is the only instance for either oil or gas engines where these best practice specifications are met 100 percent.

The data appearing in Table 4 have been used to determine the percentage of the reported engine bhp using each of the four types of cooling systems. The results appear in Table 7.

TABLE 7

TYPE OF COOLING	Natural Gas-Recycle Industry Survey, 1947. Percent of Total Engine BHP.	ASME Oil-Engine Report, 1945. Percent of Total Engine BHP.
Closed Coils and Heat Exchangers	51.1	51.4
Open Cooling Tower	28.8	34.4
Air-Cooled Radiators	14.4	2.0
Waster or Process	5.7	12.2
	100.00	100.0

From Table 7 it is apparent that the closed type of cooling system predominates to the same degree over all other systems for both industries, the one employing gas engines, and the other, oil engines. The open cooling system is second choice for both industries with a greater percentage of the oil engine using this method. Although the radiator type of cooling system is operated in accordance with the best recommended engine practice in the case of oil engines, the percentage of the total reported engine bhp employing it is the lowest, being but 2 percent. For gas engines, 14.4 percent of the total engine bhp employ the direct air cooling method. On the other hand, 12.2 percent of the oil engines bhp operate with the once through cooling system where the discharge jacket water is utilized for process purposes. This is in contrast to 5.7 percent for gas engines and which might be explained by the fact that the electric generating industry to date is far more cost conscious and aware of thermal efficiency.

General Conclusions

As a general conclusion from all the data at hand, it would appear in the light of present day ideas of good operation that the engines are operated with too low temperature water to the jackets. (Tables 4 and 6.) This might be said to apply to about 90 percent of the total installed rated engine bhp. Secondly, from the standpoint of good operation, the engines are operated with too high a temperature rise through their jackets. (Tables 4 and 5.) This might be said to apply to about 54 percent of the total installed rated engine bhp. Any of the cooling systems discussed, with the single exception of the open type cooling, can be utilized satisfactorily so as to give the desired optimum engine jacket operating conditions. Acceptance of these general conclusions offers an opportunity to discuss some of the factors which should be considered when attempting to fix the jacket water temperatures in internal combustion engines operating with natural gas fuel.

The first consideration is that the water to the engine jacket must be held constant both as regards quantity and temperature under all conditions of operation. This can be achieved in any number of dif-

ferent ways by various mechanical means and will therefore not be discussed here.

The second consideration is that the water to the jacket must not contain scale forming compounds. Although the major factor in heat removed from the cylinder wall is the water flowing over the metal surfaces, it is important that the metal through which the heat must flow to reach the water be so shaped and dimensioned that the paths of flow will be adequate for the amount of heat to be carried away. To provide correct heat flow paths is the function of the engine builder and is something over which the operator has no control. The keeping of these paths open is within the control of the operator and it is his duty to keep them open. If scale is allowed to form in the engine jacket, the purpose of the cooling water is defeated. If scale is present in the jacket, the temperature indicated by a thermometer in the water is apt to result in a false sense of security. A thermometer reading a normal 150° F. in the outlet channel is no indication of the temperature of the cylinder wall itself if this wall is covered with scale. In this case, the inside wall surface may actually be hot enough to carbonize the lubricating oil and cause excessive barrel wear. A scale of 0.020-inch in thickness can reduce the transfer of heat from the wall to the water by as much as 10 percent. For a scale thickness of 0.125-inch this reduction can become 30 percent or even 40 percent if the scale layer is 0.250-inch in thickness. For efficient and safe engine operation there must not be incomplete wetting of the metal cylinder wall in the jacket space.

Third Consideration

The third consideration is that there must be a small difference in temperature of the water entering and leaving the jacket, and engine builders now maintain that 10° F. is ideal regardless of the entering water temperature. The prime motive here is to reduce the temperature differential over the length of the cylinder, and since cylinder distortion is directly proportional to this differential, the cylinder tapering resulting from temperature is reduced. This in turn reduces casting and liner strains, lengthens their operating life and reduces excessive and unproportional wear.

In the older types of horizontal engines the inlet cooling water is generally distributed over the lower side of the jacket and forced around the cylinder barrel toward an outlet at the top of the jacket. Large temperature differentials with this type of engine tend to bow the cylinder barrel at the top because of the higher temperature at this point. For example, with a temperature differential of 50° F. the top of a 16 x 20-inch cylinder is 0.0058-inch longer than the bottom. With a 10° F. rise in water temperature, the lengthening is reduced to 0.0012-inch. In a vertical cylinder of the same size, the difference in diameter between top and bottom is 0.0052-inch for a differential temperature of 50° F., and 0.0010-inch for the case where the temperature rise is limited to 10° F. Obviously, operating with a low temperature differential, and maintaining this differential constant at all times, will eliminate excessive cylinder and piston wear.

At this point it might be well to digress and consider the piston ring with respect to the jacket water temperature differential. All cylinders are imperfect because of the distortion resulting from this differential if for no other reason. Piston rings must therefore function under this condition, with the primary purpose of sealing the combustion chamber pressure. They must also help control the lubrication of the cylinder and transfer some of the heat of the combustion chamber through the piston to the cylinder wall. And all of these functions must be accomplished with a minimum of wall friction. With the rings fitted for tightness at the top of the cylinder, in order to better hold the useful pressure, the effect of a more uniform bore resulting from a low jacket water temperature differential is to decrease the piston drag in the lower part of the cylinder and increase the mechanical efficiency.

The fourth consideration is that the quantity of cooling water through the power cylinder jackets must be sufficient to give a maximum temperature rise of 10° F. Averaging the heat release values supplied by four builders of four-cycle engines for all models equipped with exhaust manifold cooling gives 4033 Btu per bhp hour. The minimum jacket water rate is therefore 0.81 gpm per bhp hour. Thus for a 600-hp engine the water circulation through the engine should not be less than 488-gpm.

Similar data for two-cycle engines equipped with exhaust cooling are 3717 Btu per bhp hour, which results in a minimum jacket water rate of 0.74 gpm per bhp hour. For a 600-hp engine the water circulation through the power cylinder jackets should not be less than 444-gpm.

Many installations have reported water rates at double the above specified minimums, representing temperature rises through the power cylinder jackets as low as 4° F. There is no objection to increasing the circulation rates beyond the minimum values except the universal one that it requires additional pumping power. This is not necessarily a valid objection in all cases, but will depend upon each individual installation. One of the greatest drawbacks to increased water circulation is jacket design with their present too small inlet and outlet connections. Assuming that the jackets can be modified for greater flow so as to result in pressure losses not in excess of present drops, and that adequate flow line sizes will be employed, the pumping horsepower will vary directly as the circulation rate.

Larger Flow, Lower Temperature

The benefits from larger rates of flow and lower temperature rises than 10° F., through the jackets are sometimes difficult to evaluate because they are often intangible. The answer is generally to be found in better distribution through the various jackets and better heat removal which reflect in less engine downtime and less mechanical trouble over long periods of operation. Personal observation in this respect leads to the conclusion that the circulation rate should be in excess of the stated minimum and by as great an amount as possible consistent with good engineering judgment.

Resistance offered to heat flow from the combustion chamber to the cylinder wall and through the metal wall remain substantially the same for a given engine regardless of the water flow conditions in the jacket. Increasing the water rate through the jacket does, however, materially decrease the resistance to heat flow from the outside of the cylinder wall to the water. Take the case of an engine operating with

a 10° F. rise through the jackets resulting in an average water temperature of 120° F. and in an average inside wall temperature of 500° F. If the water rate is doubled, decreasing the temperature rise through the engine to 5° F., but still maintaining the same average jacket water temperature of 120° F., the average inside cylinder wall temperature will decrease about 30° F. This means that for the identical load the engine will operate at a slightly lower inside wall temperature even with the same average water temperature in the jackets.

Now if this larger water rate is maintained through the engine, but the average temperature raised to 153° F., instead of 120° F., the average inside cylinder wall temperature will not exceed 500° F. despite the higher jacket water temperature. In this case the larger circulation of water, even though at higher temperature, does not result in increasing the average inside wall temperature of the combustion chamber.

It thus is apparent that water rate through the engine jacket is a large factor in controlling the heat flow from the combustion space. Large water circulation rates are desirable because of the resulting better heat transfer, and this factor becomes more essential as operating temperatures of engines are increased. In hazarding a guess as to future trends it can be stated that jacket water circulation rates will increase, not decrease or stay fixed, and that manufacturers will eventually assist by modifying or redesigning the engine jackets.

The fifth consideration is that the temperature of the water to the engine must at least be in the range of 135 to 145° F. which will result in off-temperatures of 145 to 155° F. Engineering experience gained with various designs of engines lead to the belief that these temperatures are still conservative and that the future will see a very definite trend toward much higher operating temperatures. The limit to which the operating temperature can be raised is governed by the fundamental requisite that means must be provided for removing the heat of combustion rapidly enough to prevent the metal of the engine from reaching a destructive temperature. The temperature so established must likewise not be so high as to prevent good lubrication of the cylinder walls. Also, the temperature must not be so high as to seriously add to the discomfort of the operating personnel.

Higher Operating Temperatures Noted

In general, for satisfactory operation, the cylinder-head temperature of most engines probably should not greatly exceed 570 to 600° F. And yet we have records of Franklin automobile engines operating successfully for years with head temperatures near the exhaust valves in the neighborhood of 650 to 750° F. Further, some diesel engines have been operated in Great Britain with water at a temperature of 350° F. by maintaining the jackets under sufficient pressure to prevent steaming. Liquid-cooled aircraft engines are likewise operated successfully with fluids in the jackets in the range of 325° F. One installation of old Type 80 Cooper horizontal engine-compressors operated for years with water entering the jackets at 180° F. and leaving at 185° F. This operation was carried out despite all the dire predictions to the contrary. There is thus some precedent for advocating higher operating temperatures for internal combustion engines.

This discussion of higher operating temperatures in the engine jackets is predicated upon the condition that the temperature rise through the engine will never exceed 10° F. Stresses and expansions set up in the metal parts of the engine due to this differential can naturally be neglected.

On the other hand, the cylinder of an internal combustion engine can be likened to a furnace in which a large amount of heat is liberated at an uneven rate which results in temperature-stresses being set up in the metal parts. There are two ways of decreasing such stresses. The one is to make the cylinder wall thin, a procedure over which the builder alone has control. The other method is to lower the temperature difference between the inside and outside wall surfaces. Raising the average jacket water temperature will bring about such a decrease. Experience has shown that in water-cooled cylinders this decrease in temperature, resulting from large water flows, has reduced failures in cylinder liners caused by temperature stresses.

Results of Temperature Changes

The fact must not be overlooked that engines do not operate constantly, but are started and shut down innumerable times. The temperature changes involved here are great, and can result in trouble. This is particularly true in engines employing wet liners where the free-end is provided with some form of expansion joint. When engines so equipped are operating, these joints are tight, but upon stoppage, leakage of the jacket water over the exterior of the engine becomes a source of annoyance. In some designs this leakage is even more serious if the water can enter the crankcase. It has been observed that even with outlet jacket water temperature as low as 150 to 160° F. such leakage takes place. This situation should not be overlooked when considering even higher jacket water temperatures.

Another point for consideration in connection with high jacket water temperatures, particularly in the case of temperatures higher than 212° F., is the fact that they result in high exterior engine temperatures. This is not so serious in the case of horizontal engines, but does become a problem where the cylinders are vertical and where access to the various operating parts is from an adjacent platform. Additional heat from that of the exhaust line is given off to the engine room from the jackets and from the water lines to and from the jackets, adding to the operator's discomfort. Also, working around a hot engine, besides being disagreeable, always presents the possibility of burns to the operator, making it necessary to shroud the engine and insulate the jacket water lines. In one installation, employing 240° F. outlet jacket water successfully, the operator wore asbestos gloves when inspecting or adjusting the running engine.

The raising of the operating jacket water temperature in an engine offers no problem of control. It is just as easy to return the water to the engine at a temperature of 200 as at 140° F. The circulation rate is maintained at that required to result in a maximum temperature rise through the jackets of 10° F. and the cooling equipment designed to remove the necessary heat from the water before re-use. This is accomplished in any number of conventional ways employing temperature controls. In fact, operating at elevated temperatures results in more economic cooling equipment.

Thermal Properties of Petroleum Oils

Part II

ENTHALPIES OF SATURATED AND SUPER HEATED PETROLEUM VAPORS AT ATMOSPHERIC PRESSURE

M. VAN WINKLE,
Associate Professor of Chemical Engineering, University of Texas, Austin

VAN WINKLE

THIS SECOND article of a three-part series continues with the treatment of the thermal properties of petroleum fractions which was initiated in last month's issue of **PETROLEUM REFINER** *with "Mean Specific Heats of Petroleum Liquids and Vapors," by the same author. The third article of the series, "The Effect of Pressure on the Enthalpies of Petroleum Vapors," is scheduled for publication in the next issue.*

Enthaply-temperature charts for saturated and superheated petroleum vapors are presented in this part. Variables correlated in these charts are: 100 percent flash vaporization temperature (or dew point) of the vapor, slope of the flash curve, API gravity, and UOP characterization factor, K. The data were computed from existing correlations of the various physical and thermal properties of petroleum oils.

A new method for computation of petroleum vapor enthalpies is introduced wherein the vaporization characteristics of petroleum fractions are correlated directly with heat content of saturated vapors at their dew point. The principal advantage of this method lies in its usefulness in fixing the state (liquid or vapor) of a particular stock at atmospheric pressure at a definite temperature.

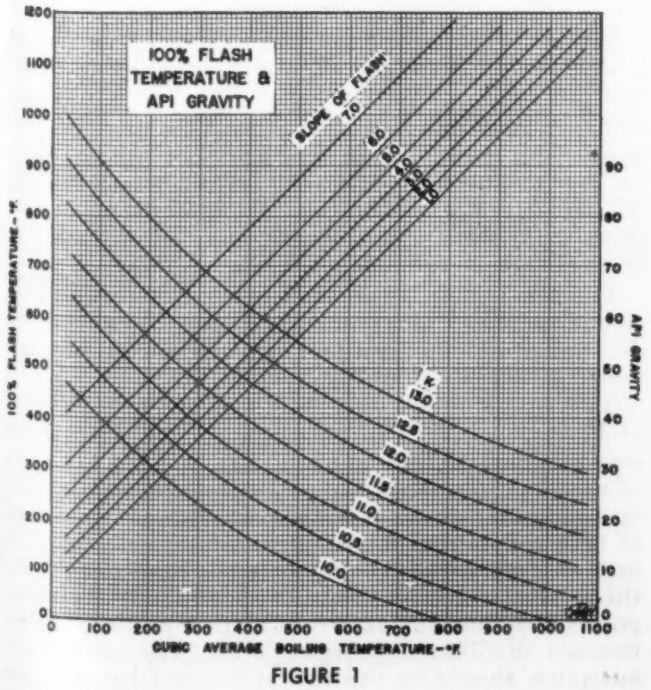


FIGURE 1

IN AN equilibrium flash vaporization operation involving petroleum oils such as characterized by vapor-liquid equilibrium on a fractionating plate, it is theoretically evident that for a feed of definite characteristics to the plate, there is a definite composition of liquid and vapor at each temperature and pressure. With the pressure constant, the vapor and liquid compositions and relative quantities are fixed at each temperature. It is also evident that the enthalpy (or heat content at constant pressure) is fixed for both the vapor and liquid. Since the difference between the enthalpy of the vapor and liquid at the temperature and pressure of the equilibrium and their enthalpies at an arbitrarily defined reference state and temperature is an exact differential mathematically, and independent of the thermodynamic path followed to evaluate the enthalpy difference, it is possible to determine the enthalpy difference by several methods if sufficient data are available.

The exact but most difficult method of evaluating

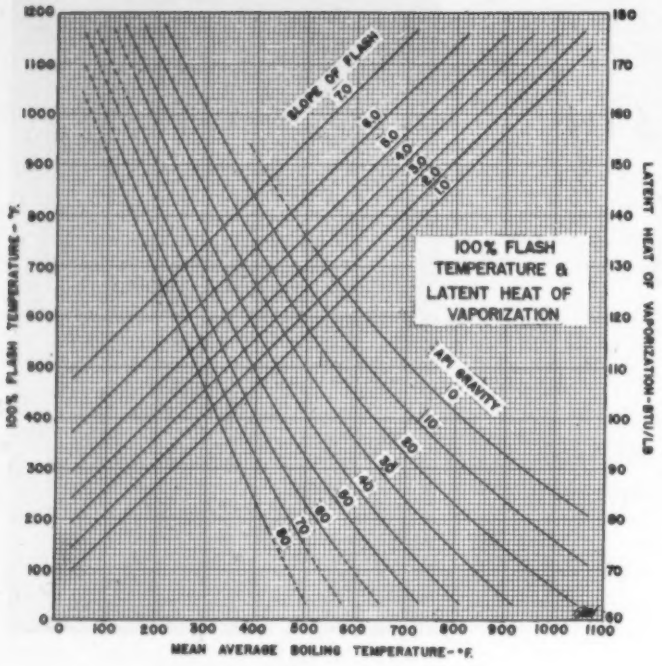


FIGURE 2

enthalpy of a petroleum oil is to consider the whole oil divided into a sufficient number of small fractions so that each fraction represents a pure compound of definite boiling point, specific heat, latent heat of vaporization, etc. Then assuming perfect fractionation in the formation of the vapor from the original liquid as the temperature is raised from the reference temperature to the final temperature at which the equilibrium exists, evaluate the enthalpy of each "compound" including the sensible enthalpy of the liquid from the reference temperature to the boiling point, the latent heat of vaporization at the boiling point, and the sensible enthalpy of the vapor from the boiling point to the equilibrium temperature, t, for those compounds whose boiling points lie below t. For those components whose boiling points lie above t, the enthalpies would be sensible enthalpies of the liquid. The total enthalpy would then consist of the summation of all of the individual enthalpies of all of the compounds referred to the same temperature, pressure, and state. This assumes negligible heat mixing, which is generally true for petroleum oils. Unfortunately, the difficulties inherent in this method are sufficiently great to make it highly impractical.

The common method[1] for computing the enthalpy of vapor-liquid mixtures of petroleum is to assume the vapor to be formed at some temperature, t_m, empirically defined as an average boiling point (usually the mean average boiling point[2]). The enthalpy of the liquid portion of the mixture is computed from specific heat data as sensible enthalpy of the liquid from the reference temperature to t_m. The enthalpy of the vapor portion of the mixture is then computed by assuming vaporization at the reference temperature and correcting the latent heat from its value at t_m to the value at the reference temperature, t.

Petroleum enthalpy-temperature charts computed by this method are thermodynamically sound. However, the usual chart prepared by this method tends to indicate impossible physical situations in that stocks which are not liquids at high temperature and atmospheric pressure have liquid enthalpies indicated, and stocks which are definitely liquid at lower temperatures and atmospheric pressure have vapor enthalpies indicated for them. In addition, at a temperature where both liquid and vapor could exist at atmospheric pressure (a purely hypothetical temperature because a petroleum mixture differentially vaporizes over a range of temperature), subtraction of the liquid enthalpy from the vapor enthalpy will rarely give the latent heat of vaporization at that temperature.

Proposed Method of Computing Saturated Vapor Enthalpy

A method of evaluating enthalpies of petroleum vapors, which minimizes the above objections has been developed. This method arbitrarily assumes vaporization of the vapor fraction at its dew point (or 100 percent flash vaporization temperature). On this basis the enthalpy of the saturated vapor is computed as follows:

$$H_{SG} = c_{p\,Lm}\,(t_{DP} - t_1) + \lambda_{tm} \qquad (1)$$

where H_{SG} = the saturated vapor enthalpy, Btu/lb.

$c_{p\,Lm}$ = mean specific heat of the liquid over the temperature range from t_1 to the dew point, Btu/lb.—°F.

t_{DP} = the dew point temperature, °F.

t_1 = the reference temperature, °F.

λ_{tm} = latent heat of vaporization at the mean average boiling point of the vapor fraction.

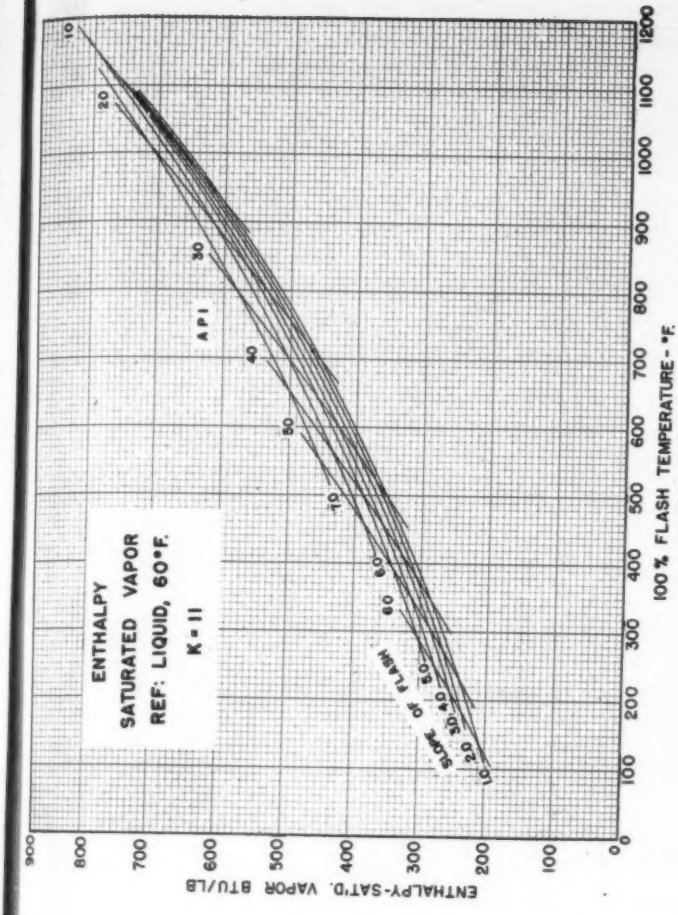
Correlation of Petroleum Properties with 100 Percent Flash Vaporization Temperature and Slope of Flash Curve

In practically all cases in design computations involving vaporization and condensation of petroleum oils, it is necessary to determine the flash vaporization curves of the oils in question. Because vaporization and condensation involve heat transfer and necessity for evaluation of enthalpies for heat balance computations, it was considered desirable to correlate the physically significant vaporization characteristics of dew point (100 percent flash vaporization temperature) and slope of flash curve with saturated and superheated vapor enthalpies.

Before the data for such charts could be computed it was necessary to correlate the physical and thermal properties of API gravity, K value, and latent heat of vaporization with the flash curve characteristics. This was done by using the 50 percent flash vs. 50 percent ASTM temperature, and flash slope and ASTM slope correlations of Nelson[3] and the correlations of Watson and coworkers[1,4-6] for the general properties of petroleum.

Figures 1 and 2 were constructed from data derived from seven different correlations to enable quick determination of the properties of petroleum through which enthalpies could be evaluated.

Two assumptions were involved in the derivation of Figures 1 and 2. In all cases: 1) the flash curve was assumed to be a straight line, and 2) the ratio of the 50 percent flash temperature to the mean average and cubic average boiling points was considered to be a constant at a constant flash curve slope. The first assumption is commonly made, and computing the slope on the basis of the 10 percent and 70 percent points introduces small error except for stocks having unusual distillation characteristics. The second assumption should be theoretically sound but was not



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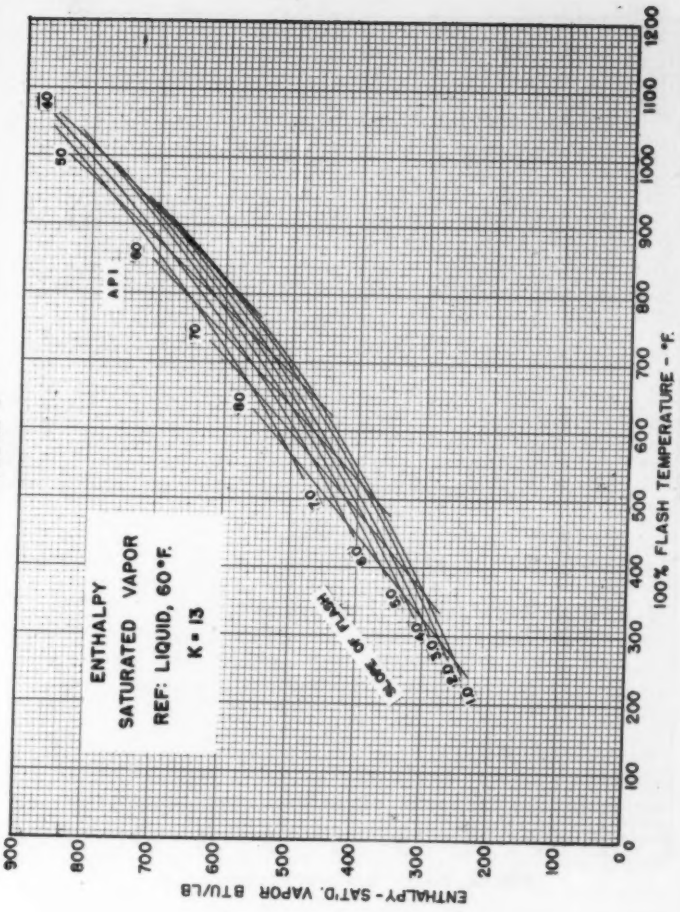

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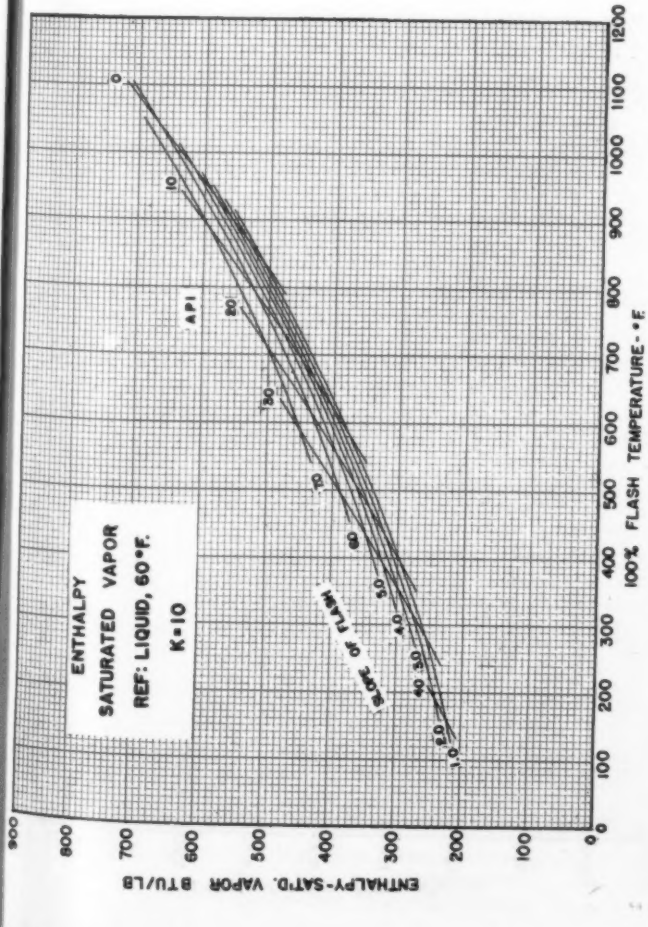

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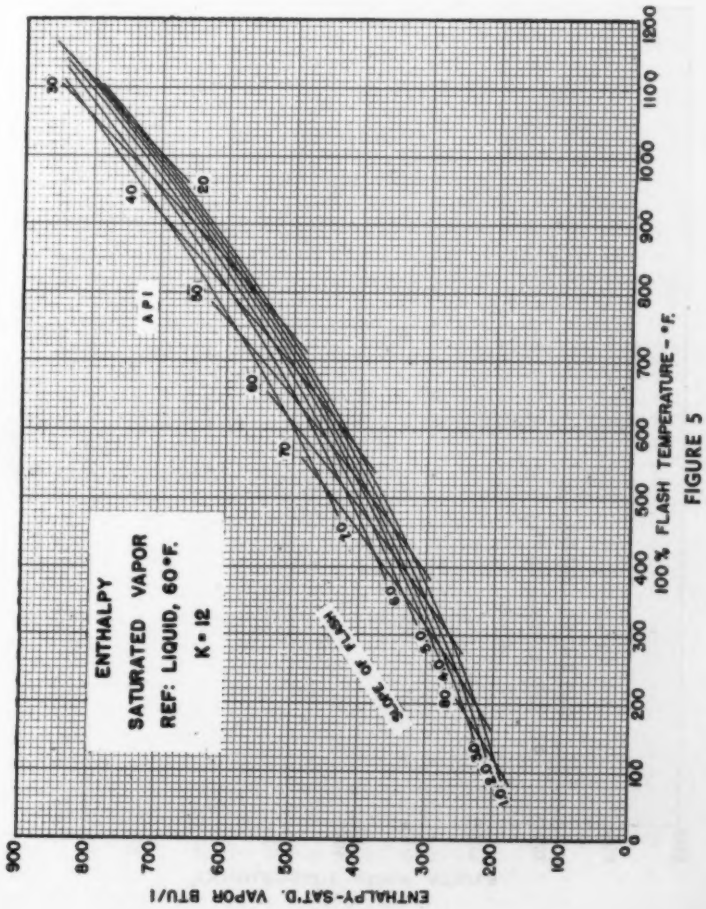

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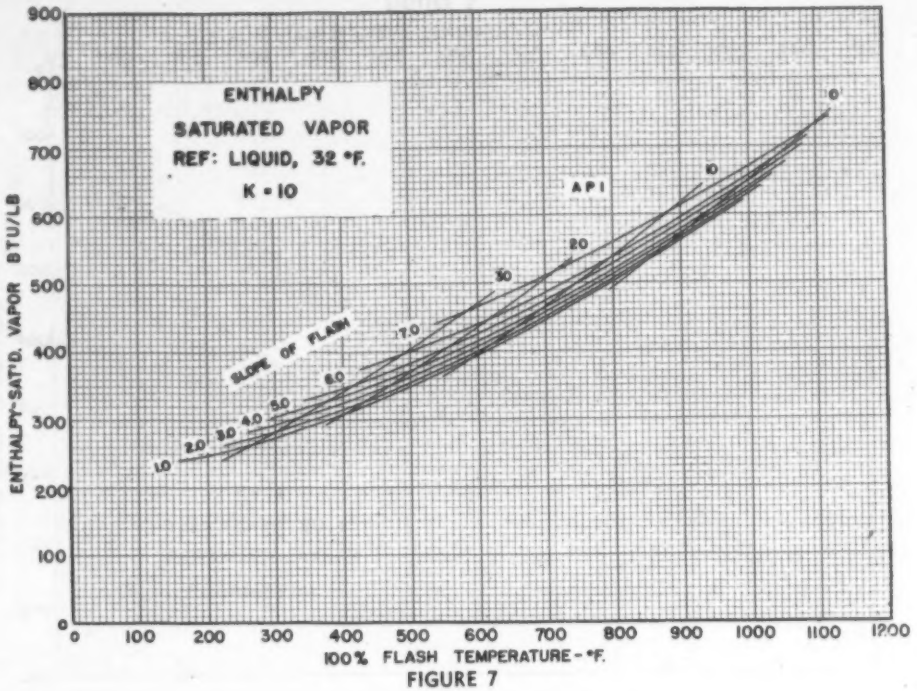

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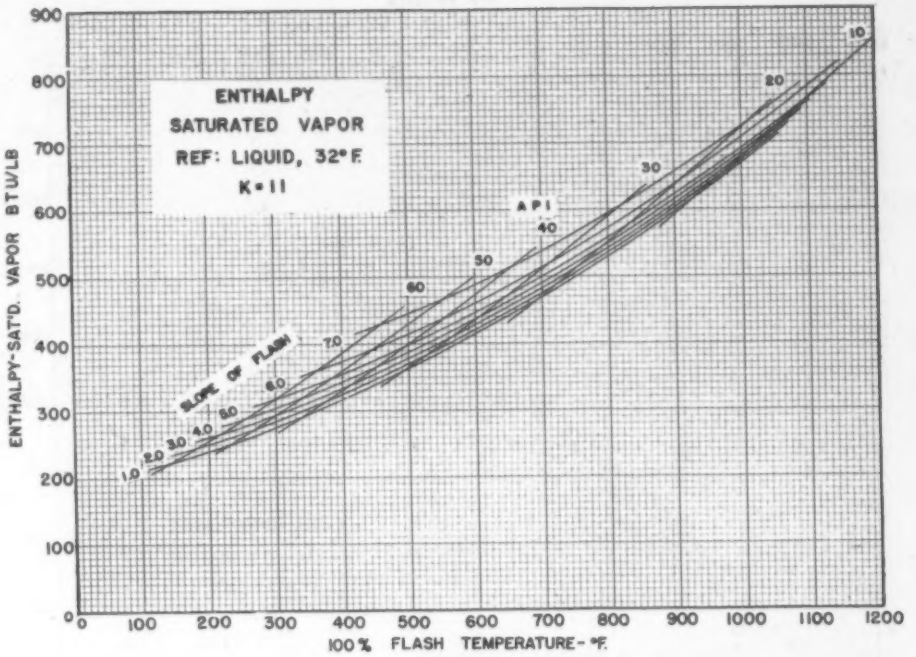

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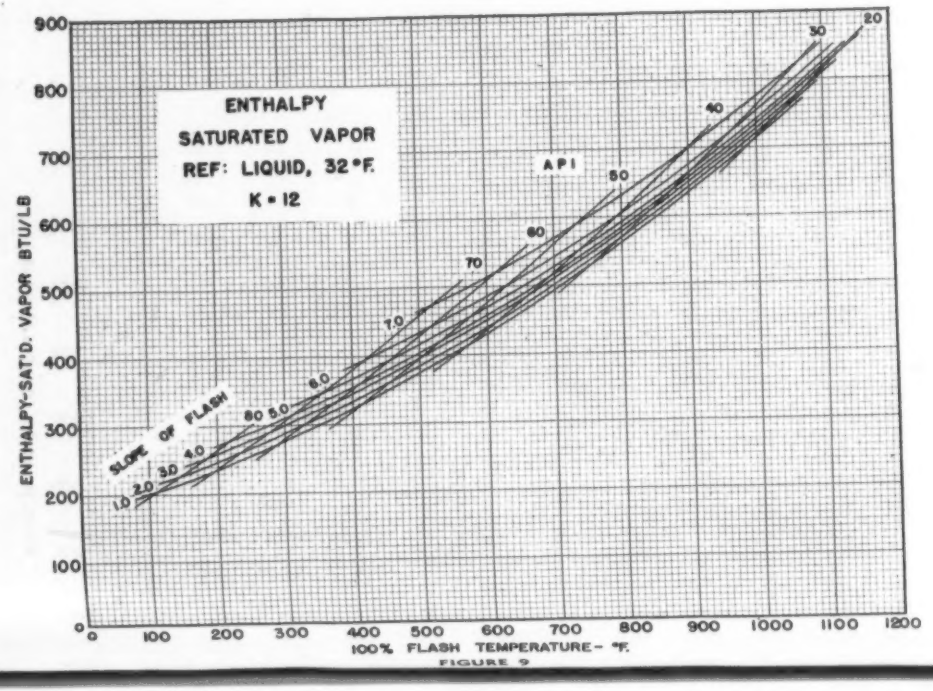

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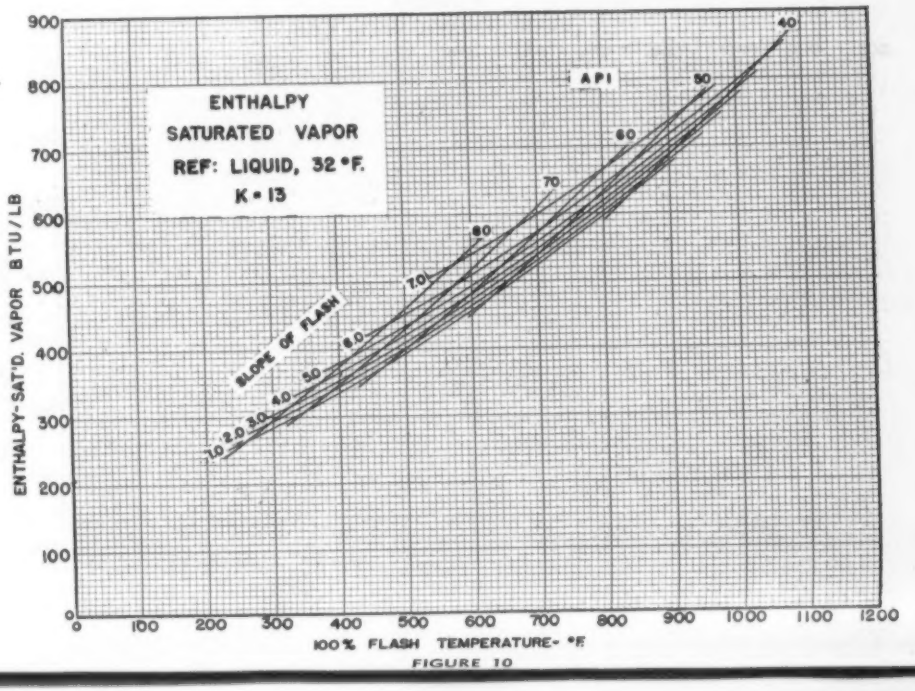

FIGURE 10

supported by data derived from Watson's boiling point correlations. A considerable amount of smoothing was necessitated to determine the slope of the slope curves and to establish their spacing.

Use of Figures 1 and 2 is illustrated by the following example:

Example 1. Determine the latent heat of vaporization of a petroleum oil stock whose dew point = 500° F., slope of flash = 3.0, and K = 11.5

Solution: Follow the 100 percent flash vaporization temperature ordinate (Figure 1) corresponding to 500° F. to the right to the line where the slope = 3.0. Follow the line indicated by the intersection parallel to the ordinate to the curved line corresponding to K = 11.5. Then read the API gravity = 42 on the right hand ordinate. Repeat the first step shown above on Figure 2, then following a line from the intersection of the slope curve to the curved line corresponding to API = 42 and then to the right hand ordinate. The latent heat of vaporization = 126 Btu/lb.

Enthalpy Charts for Saturated Vapors

Use of these charts and mean specific heat charts[7] enabled the computation of data from which Figures 3 to 10 inclusive were plotted. Figures 3 to 6 inclusive are based on a reference temperature of 60° F. and the liquid state, and Figures 7 to 10 inclusive based on 32° F. and the liquid state. Each figure represents saturated vapor enthalpy correlated with 100 percent flash vaporization temperature, slope of flash, and API gravity at a single value for K = 10, 11, 12, or 13.

For the value of K indicated, the enthalpy of the saturated vapor at its dew point may be read directly from the charts if the API gravity or flash slope of the oil is known. For values of K intermediate between those which the charts represent, interpolations must be made on the basis of *constant flash slope* and not on the basis of constant API gravity.

Enthalpy of Superheated Vapors at Atmospheric Pressure

Consistent with the above method of computation of saturated vapor enthalpy, the enthalpy of superheated vapor (at temperatures above the dew point) was evaluated by means of equation (2).

$$H_{(t_1 \rightarrow t_2)} = {}_{c_{pL}}{}_{(t_1 \rightarrow t_{DP})} (t_{DP} - t_1) + \lambda_{t_m} + \left[{}_{c_{pv}}{}_{(t_1 \rightarrow t_2)} (t_2 - t_1) - {}_{c_{pv}}{}_{(t_1 \rightarrow t_{DP})} (t_{DP} - t_1) \right] \quad (2)$$

where

$H_{(t_1 \rightarrow t_2)}$ = enthalpy of super-heated vapor Btu/lb.

${}_{c_{pL}}{}_{(t_1 \rightarrow t_{DP})}$ = mean specific heat of liquid from t_1 to t_{DP}, Btu/lb.—°F.

${}_{c_{pv}}{}_{(t_1 \rightarrow t_2)}$ = mean specific heat of vapor from t_1 to t_2, Btu/lb.—°F.

${}_{c_{pv}}{}_{(t_1 \rightarrow t_{DP})}$ = mean specific heat of vapor from t_1 to t_{DP}, Btu/lb.—°F.

λ_{t_m} = latent heat of vaporization at t_m, Btu/lb.

t_1, t_m, t_{DP}, t_2 = reference temperature, mean average boiling point, dew point temperature, and final temperature, °F., respectively.

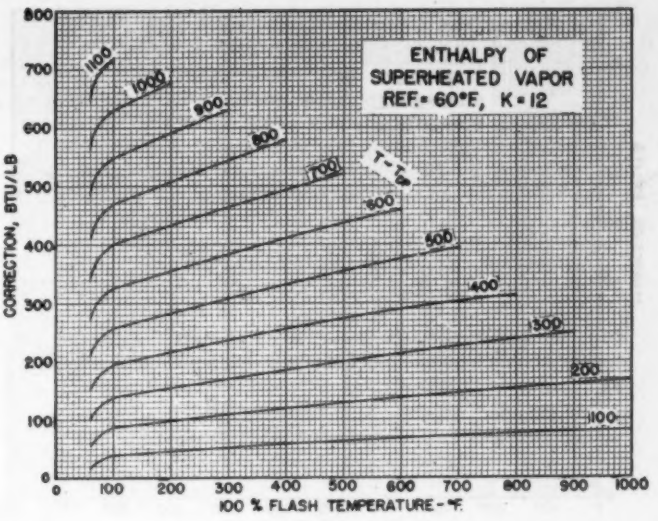

FIGURE 11

Because of the impracticality of representing the variable of superheat on charts such as those in Figures 3 to 10, Figures 11, 12, and 13 were devised for use in conjunction with Figures 3 to 10 for graphical solution of the superheated vapor enthalpy. Figure 11, based on a reference temperature of 60° F. and Figure 12, 32° F., both for K = 12.0 represent enthalpy corrections plotted at lines of constant temperature differences between the actual temperature at which the vapor exists and its dew point vs. the dew point temperature.

Figure 13 represents a modification of the correction factor for values of K other than 12, and is a cross plot for superheat correction vs. the actual temperature-dew point difference for K = 12, with a supplementary factor chart for correcting for other values of K. For values of temperature difference above 100° F. the correction is the same for both reference temperatures, 32° F. and 60° F. For values below 100° F. there is a slight difference as shown on Figure 13.

Figure 14 is an example of an enthalpy-temperature chart based on a reference temperature of 60° F. and the liquid state for 20, 40, and 60 API gravity stocks, K = 12.0 and slope of flash = 3.0. Such a chart serves

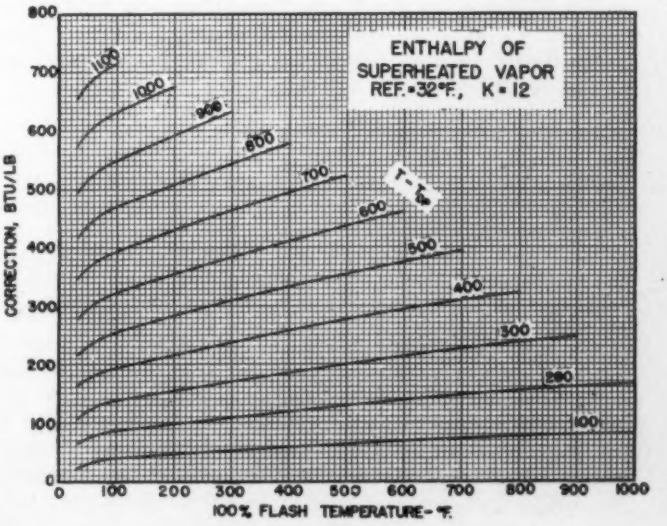

FIGURE 12

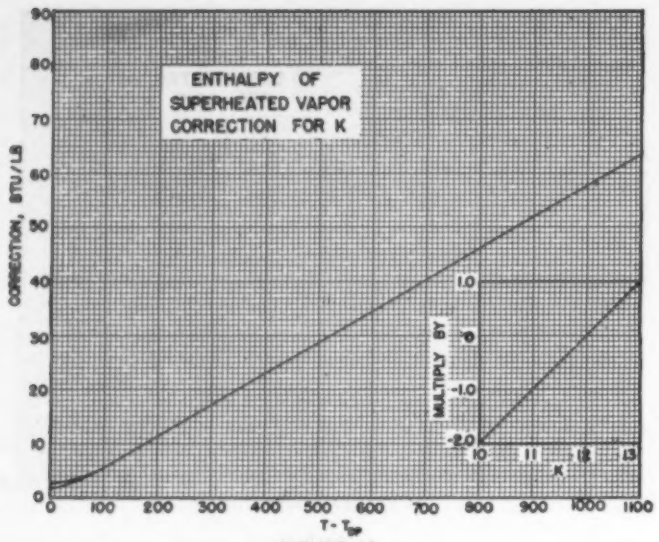

FIGURE 13

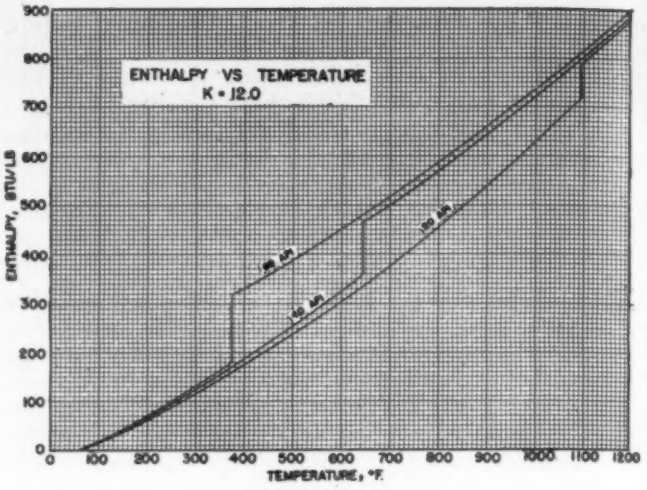

FIGURE 14

to illustrate the complete characterization of the stocks in regard to enthalpy, temperature, and state in accordance with the assumptions listed above. The deviation of such plots from physical fact lie in the sharp vertical rise in the enthalpy-temperature relation at the dew point temperature. Actually, if it were possible to evaluate the enthalpy change in the differential vaporization of the stock from all liquid to all vapor, the enthalpy-temperature curve would have the same curvature as that shown for the liquid up to the bubble point. At this point the curvature would increase, because of the latent heat effects of the differential fractions being vaporized, up to the dew point temperature. At this temperature the curvature would level out and follow the same conformity as the vapor enthalpy temperature relation.

It is believed that enthalpies of petroleum vapors computed by the methods outlined above are as accurate as those determined by the commonly accepted methods and are theoretically more consistent with the actual physical mechanism of equilibrium flash vaporization and condensation. Unfortunately, lack of sufficient published experimental data prevents an accurate check of enthalpies obtained by this method.

Examples in the Use of the Charts

Example 1. A 35-API stock having a flash slope of 2.5 and K = 11.0 is to be vaporized and heated to 600° F. at atmospheric pressure. What is the enthalpy of this material at 600° F. referred to the liquid state at 60° F?

Solution:

100 percent flash temperature	= 460° F.	Fig. 1
Saturated enthalpy at 460° F.	= 345 Btu/lb.	Fig. 4
$t - t_{DP}$	= 140° F.	
Enthalpy correction for superheat (K = 12)	= 90 Btu/lb.	Fig. 11
Enthalpy correction for K = 11.0 = (—1.0) (8)	= —8 Btu/lb.	Fig. 13
Total enthalpy = 345 + 90 — 8 = 427 Btu/lb.		*(Ans.)*

Example 2. A gasoline vapor from a topping column at 380° F. having an API gravity of 60, is condensed and cooled at atmospheric pressure to 100° F. How much heat is removed in the condenser-cooler per pound of gasoline?

Solution:

100 percent vaporization temperature	= 380° F.	
K value	= 19.4	Fig. 1
Saturated enthalpy (K = 12.0, slope = 1.5)	= 308 Btu/lb.	Fig. 5
Saturated enthalpy (K = 13.0, slope = 1.5)	= 312 Btu/lb.	Fig. 6
Saturated enthalpy (K = 12.4, slope = 1.5)	= 310 Btu/lb.	
Enthalpy of liquid at 100° F.	= 218 Btu/lb.	Ref. 7
Heat removed/lb. gasoline = 310—118	= 292 Btu/lb.	*(Ans.)*

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Prevention of Corrosion IN REFINERY Heat-Exchanger Equipment

M. A. FURTH, Smiths Bluff Refinery, The Pure Oil Company
Nederland, Texas

FACTORS which must be considered in heat-exchanger corrosion problems are many and varied and frequently it is impossible to evaluate some of them accurately. Use of alloys will continue to be economical, this in the absence of economical means for removal or neutralization of corrosives and the development of new alloys must be followed carefully. However, careful consideration of service conditions and proper material specifications will substantially reduce the petroleum refiner's heat-exchanger corrosion problems.

CORROSION control is usually effected through such means as: selection of crudes; chemical neutralization; or the use of corrosion-resistant metal alloys. In evaluating the effects of corrosion and the relative value of various methods of control, the type of heat-exchanger equipment must also be considered. This paper has been confined to a discussion of the corrosive media, methods of control, and types of exchanger equipment that have been encountered at the Smiths Bluff, Texas, refinery of The Pure Oil Company.

At the Smiths Bluff refinery the two types of heat exchangers in most common use and the relative extent of their usage are 1) Shell-and-tube—approximately 67 percent of total installed surface; and 2) Submerged bundles in water—approximately 21 percent of total installed surface.

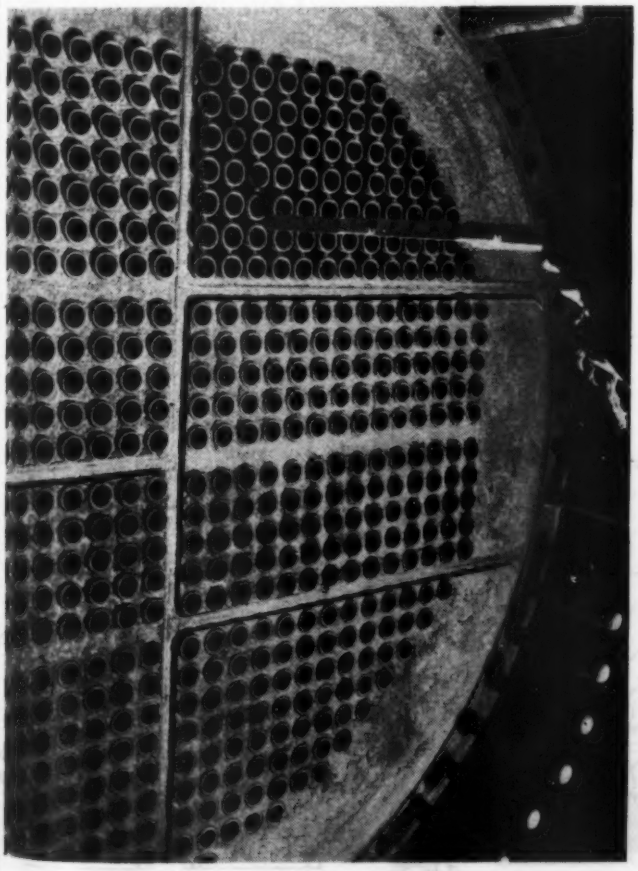


FIGURE 1—An Illustration of the Effect of Temperature on Sulfur Corrosion.

Note that the face of the carbon-steel tube sheet at the inlet pass (upper right-hand), which handles heavy cracked distillate recycle at 700 deg. F., has lost approximately ⅝ in.; whereas the outlet pass at 400 deg. F. (lower right-hand) shows no loss. All tubes are assembled into tube sheet so as to project ⅛ in. beyond original face of tube sheet.

Shell-and-tube exchangers at this plant are of conventional design. Although there are a few of them using ¾-inch-od. tubes, the plant has standardized on the use of 1-inch-od. 16-foot long tubes, arranged on 1¼-inch square pitch. This type of exchanger is being used for condensing, cooling, preheating, reboiling, etc.

The submerged bundles consist of a pair of tube sheets approximately 16 inches wide and 69 inches high, into which from 168 to 228 tubes have been expanded in the same manner as in the tube sheets of a shell-and-tube exchanger. The tubes have been standardized at 1-inch-od., 14-gage, 22-foot-long. These bundles are merely set side by side in an open-top water box into which water is introduced. Tube-sheet heads provide the means for vapor and liquid inlet and outlet connections, and are provided with suitable pass baffling.

The most common corrosive agents have been: a) Sulfur and sulfur compounds. b) Hydrochloric acid. c) Organic acids. d) Ammonia and ammonia compounds. e) Oxygen.

Each of these corrosives behaves differently under different conditions. The problem is further complicated by the fact that corrosion is often due to a combination of several corrosive media and conditions that make it difficult to determine the exact extent for which each corrosive condition is responsible. Different types of crude have been found to cause wide variations in corrosion patterns and rates. In this plant crudes have been generally classified as sweet, East Texas, and Louisiana types.

High-temperature sulfur corrosion, as experienced

in heavy cracked distillate recycle systems at temperatures of approximately 675 to 750° F., results in corrosion rates ranging from 0.070 to 0.150 inch per year on carbon steel. The rate, of course, is largely dependent on temperature, velocity and impingement effects; hence the wide variation. The use of 4.0- to 6.0-percent-chromium 0.5-percent-molybdenum alloy (hereafter referred to as 5-percent-chrome-alloy steel) for this service has reduced corrosion rate to a maximum of 0.008 inch per year.

Hydrogen sulfide has been found in minor amounts in straight-run or virgin gasoline and naphtha streams from all sweet crudes. Hydrochloric acid, produced from salts in the crude during processing, has also been found in these same streams. Hydrogen-chloride corrosion has been a severe problem in one unit which is running a crude mix with a maximum salt content of 125 pounds per 1000 bbl. In this case the corrosion rate on carbon steel has been measured at more than 1.5 inches per year in localized areas. Ammonia injection has been successfully used in reducing this corrosion rate appreciably.

In thermal cracking-unit systems both sulfur compounds and organic acids are found. The latter have been experienced in serious quantities when crudes containing appreciable amounts of esters are processed. These acids are well distributed throughout the streams, but give most trouble in the presence of water and steam. Formic, acetic, proprionic, and butyric acids are present in the gas-handling and gasoline streams. Coupled with hydrogen sulfide, they are a severe corrosion problem in gasoline stabilizers and gas plants. Ammonia is useful in reducing the attack near points of injection. However, it has been limited in use; because, if sufficient quantities are used to control acid attack, it usually results in ammonia attack on non-ferrous exchanger tubes at other points in the system. Caustic washing is a more positive means of removal of these acids when they are present in large quantities. It also must be done at such a location and in such a manner that satisfactory removal of the caustic is accomplished, and so that damage to non-ferrous materials at other points in the system will be prevented. When a crude mix containing from 25 to 66 percent Van Zandt crude is run, the amount of acids present in the unstabilized cracked-gasoline stream will require from 31 to 81 pounds, respectively, of sodium hydroxide (NaOH) per 1000 barrels of gasoline for neutralization. Under such conditions and without neutralization, corrosion rates of 0.068 inch per year are experienced on carbon steel wherever acid waters collect.

In the case of thermofor catalytic cracking, the corrosives are mainly ammonia and hydrogen sulfide which result from the cracking process. Corrosion from these sources is severe in the gas-plant section, and has led to crack failures of admiralty tubing in condensers, principally in depropanizer and debutanizer systems; 70-30 cupro-nickel tubes are now on trial as an alternate for admiralty which has not been satisfactory in these systems. No data are available at this time. No chemical neutralization has been attempted.

Losses by oxygen are associated with water. The dissolved oxygen content of approximately 7 ppm plus total chlorides (expressed as sodium chloride) of 1100 ppm of the cooling water is of such proportion as to cause dezincification losses in plain admiralty tubing with water temperatures of from 90 to 150° F. This form of loss was effectively prevented in most cases by the use of either copper alloys with little or no zinc; or admiralty tubing of the inhibited variety, using less than 0.10 percent of either arsenic, phosphorus, or antimony as the inhibitor.

Similar water, except with salt content varying between 600 and 1000 ppm, when used for boiler feed water continued to give evidence of very slight dezincification of inhibited admiralty in the temperature range of 150 to 250° F. Tube life was not materially affected, as the controlling factor was corrosion from the process side. The use of soft and deaerated water has completely corrected this situation.

Former heavy losses on water-exposed steel surfaces of feed-water preheaters have also been reduced by the use of softened and deaerated water. The reduction is due to elimination of oxygen pitting. Remaining corrosion losses are principally due to the anodic relationship of steel and iron to copper or brass used for tubes.

Preparation of Equipment for Increased Corrosion Resistance

Complete elimination or neutralization of corrosives is seldom economical or feasible. The selection of suitable corrosion-resistant alloys, as well as their economical usage, is usually a desirable adjunct to

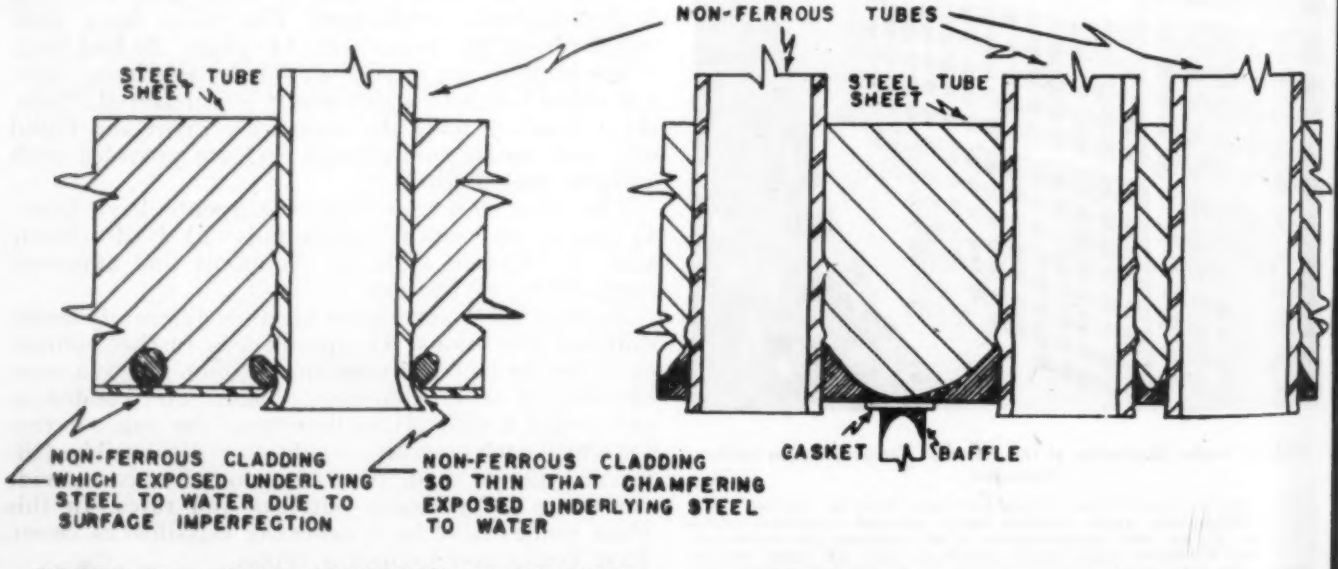

NON-FERROUS TUBES
STEEL TUBE SHEET
STEEL TUBE SHEET
NON-FERROUS CLADDING WHICH EXPOSED UNDERLYING STEEL TO WATER DUE TO SURFACE IMPERFECTION
NON-FERROUS CLADDING SO THIN THAT CHAMFERING EXPOSED UNDERLYING STEEL TO WATER
GASKET
BAFFLE
METAL REMOVED BY CORROSION

FIGURE 2—Common Failures of Steel Tube Sheets in Water Service

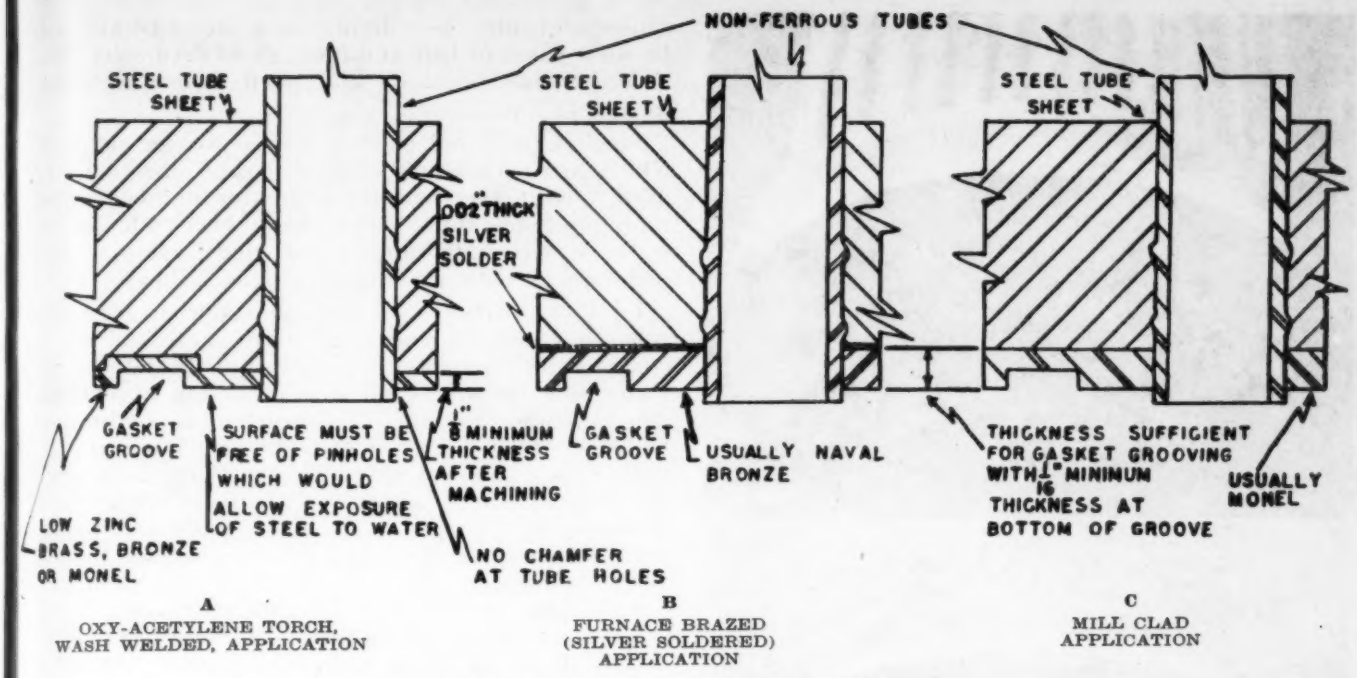

NON-FERROUS TUBES
STEEL TUBE SHEET
STEEL TUBE SHEET
STEEL TUBE SHEET
.002" THICK SILVER SOLDER
GASKET GROOVE
SURFACE MUST BE FREE OF PINHOLES WHICH WOULD ALLOW EXPOSURE OF STEEL TO WATER
1/8" MINIMUM THICKNESS AFTER MACHINING
GASKET GROOVE
USUALLY NAVAL BRONZE
THICKNESS SUFFICIENT FOR GASKET GROOVING WITH 1/16" MINIMUM THICKNESS AT BOTTOM OF GROOVE
USUALLY MONEL
LOW ZINC BRASS, BRONZE OR MONEL
NO CHAMFER AT TUBE HOLES
A
OXY-ACETYLENE TORCH, WASH WELDED, APPLICATION
B
FURNACE BRAZED (SILVER SOLDERED) APPLICATION
C
MILL CLAD APPLICATION

FIGURE 3—Alternative Types of Non-Ferrous Cladding

neutralization efforts, and in many cases alloys are the only practical method of corrosion control.

The application of alloys is expensive; therefore good judgment must be exercised in their selection as well as in determining the extent of application. The economy of application depends on a number of factors, among them:

1. **Importance to operations:** In corrosive services, where the continuity of operation of a process unit depends upon a particular exchanger, the use of corrosion-resistant alloys is almost mandatory.

In services where an exchanger is not a vital link in the process but, nevertheless, is important from a heat-conservation viewpoint, economics may favor alloys which will assure continuity of service.

2. **Maintenance costs:** Excessive maintenance charges will result from frequent retubing or replacement of parts. Higher priced alloys which will render longer service life can frequently be justified on the basis of reduced maintenance costs.

In general, the basis of comparison is cast-iron, carbon-steel, or copper-zinc alloys of appropriate thickness. The substitution of more expensive corrosion-resistant alloys should be based on individual evaluation of each of the exchanger parts. As a general rule it has been found advisable to make the original installation using the more common ferrous and non-ferrous metals, provided they are known to be reasonably well suited to the service. Subsequent experience is used as a guide to the selection of more expensive alloys for replacements.

Tubes—Tubes are one of the most difficult and expensive of exchanger-parts replacements, at least insofar as labor is concerned. If 1-inch-od, 12-gauge, 16-foot-long steel tubes and 1-inch-od, 14-gauge, 16-foot-long inhibited admiralty tubes are used, the labor cost of removal and replacement usually runs in the neighborhood of $1.25 and $1.00 per tube, respectively. This is equivalent to 30 cents and 24 cents per square foot of exchanger surface for the two respective types of metals.

For condensing and cooling service, with water as the coolant, inhibited admiralty has been adequate except where ammonia and hydrogen sulfide are present in such quantities and under such conditions as to promote stress corrosion or corrosion-fatigue failures; 70-30 cupro-nickel tubes are now on trial at such points. In one case the trial is now a year old with no evidence of cracking, although the corrosion rate is apparently greater. Based on comparative

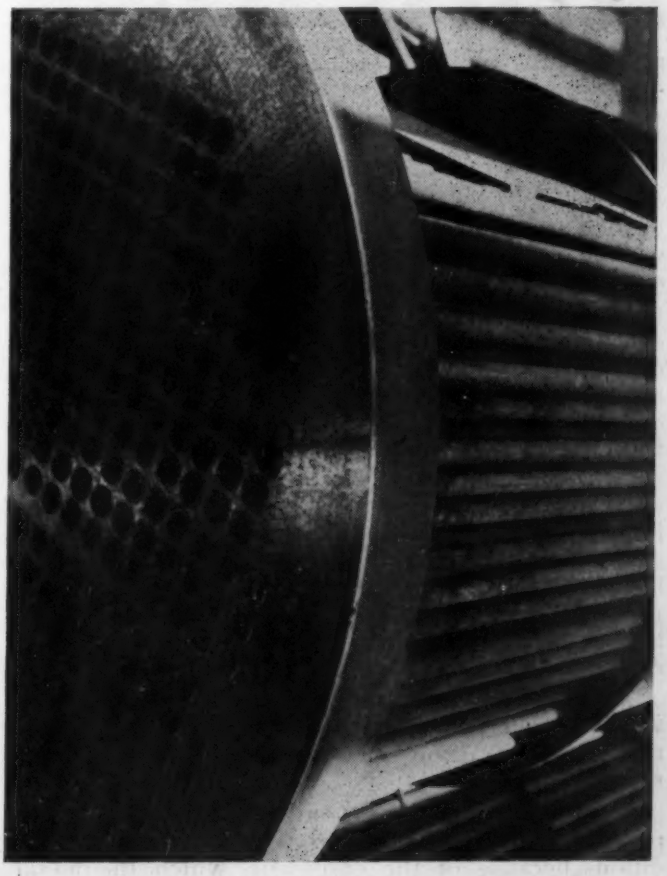


FIGURE 4—A Wash-Welded Type of Monel-Clad Tube Sheet for Water Service

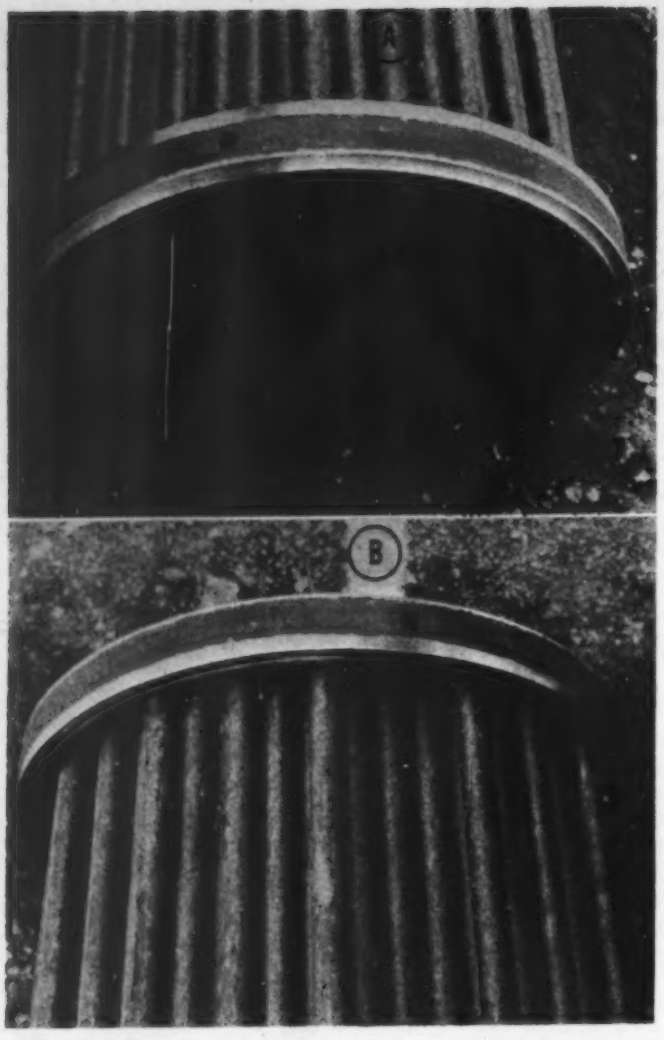


FIGURE 5—Two Views of a Floating Tube Sheet Which Has Been Reclaimed and Used in a Rebuilt Bundle

Attack is by organic acids on the shell side of the exchanger. The gasket surface and the groove for engagement of the split ring have been rebuilt with 18-8 molybdenum AISI No. 316 stainless-steel welding rod and remachined.

metal costs, an increase of approximately one-third in tube life will be required to justify using the more expensive alloy.

Carbon steel is the basic material for the oil-to-oil exchanger service. In cases in which hydrochloric or organic acids have been involved, admiralty metal has sometimes proved to be preferable. In the case of high-temperature sulfur corrosion (range 650 to 900° F.) 5-percent chrome-alloy-steel tubes are used successfully, and have a service life several times that of carbon steel. Use of this alloy will result in a cost increase of 110 percent as compared with carbon steel, or approximately $1.00 per square foot of retubed bundle surface. Exchanger tubes are frequently subject to corrosive attack from both sides, and it may be difficult to find a metal which will withstand both corrosives.

Tube Sheets for Water Service—Basic material for water service has been naval bronze. Current practices include carbon-steel tube sheets with non-ferrous facings.

Naval bronze, or other non-ferrous material, is not particularly well adapted to retubing under field conditions because of the ease with which the metal deforms. While tubes are expanded into the sheet, very good control is required if over-expansion and consequent tube-sheet deformation are to be avoided. In some cases of field retubing, sheet diameters have been increased as much as ¼-inch, with visible distortion of the face.

Steel is preferred because of its greater strength, which strength permits thinner tube sheets to be used, and it also permits a greater number of retubings. Steel tube sheets have been adapted to water service with non-ferrous tubes, using several techniques—with varying results as follows:

1). Plain carbon-steel tube sheets with admiralty tubes have been found moderately successful where considerable corrosion allowance can be left on the water side and where no pass gasketing is required. The ratio and proximity of exposed areas of admiralty and steel are such that electrolytic attack is serious—with losses running up to ⅜-inch deep, in annular pits around tubes—within 2 years' time. Under these circumstances gasket surfaces for pass baffling become seriously impaired by undermining (see Figures 2-A).

2). Paints have been tried with no success.

3). Tinning has been a failure, because of pin holes which allow corrosion to start and then blister off the solder coat.

4). First attempts at acetylene-torch-brazed surfacing were unsuccessful because of the unfortunate selection of high-zinc materials which resulted in serious and rapid dezincification. Surfacing so affected spalled off.

5). Next attempts utilized low-zinc (16 percent or less) brazing rods with good results, at least insofar as dezincification was concerned. However, tube-sheet life was seriously impaired and limited by large voids which were corroded in the steel (under the bronze) by electrolytic means. The fault lay in a bronze deposit of insufficient thickness, which in some cases included pin holes. Tiny annular areas of steel were exposed around tubes where chamfering had removed the bronze, or at the bottom of the pin holes through the bronze. The unfavorable relationship of steel and brass areas exposed to the electrolyte led to extremely damaging losses under the brass surfacing (see Figure 2-B).

6). Successfully brazed surfaces have been ac-

FIGURE 6—An Example of 18-8 Molybdenum AISI No. 316 Stainless Steel Cladding, After a Year of Service, Where Organic-Acid Corrosion Is Bad.

Note thin, corroded, carbon-steel tube ends as compared to new condition of alloy surfacing. Outer limit of alloy-welded facing is visible between bolt holes.

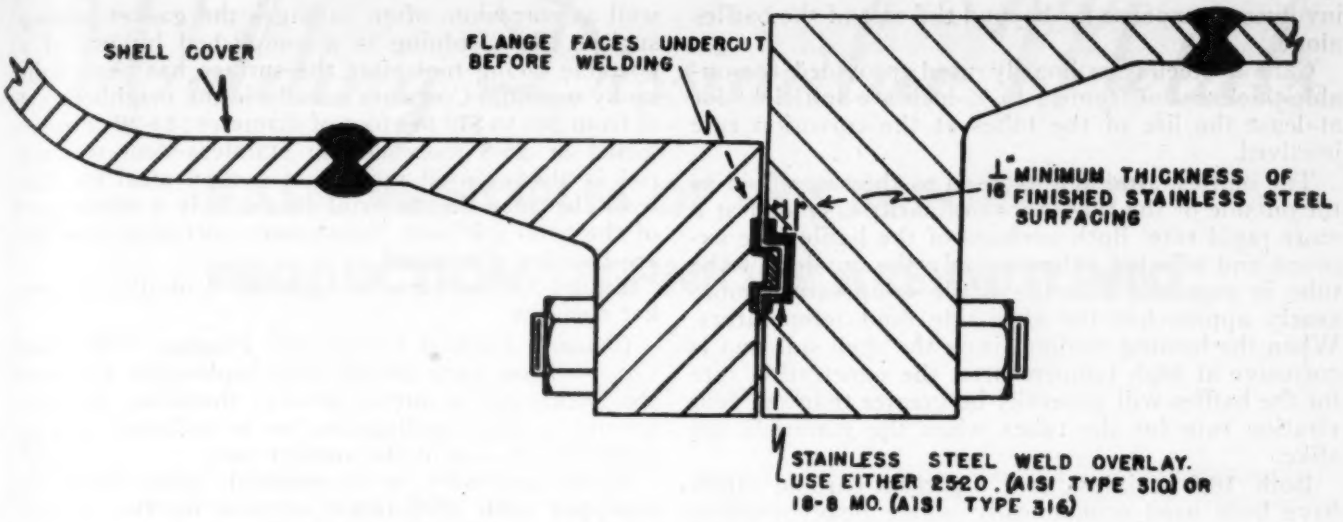

SHELL COVER
FLANGE FACES UNDERCUT BEFORE WELDING
1/16" MINIMUM THICKNESS OF FINISHED STAINLESS STEEL SURFACING
STAINLESS STEEL WELD OVERLAY. USE EITHER 25-20. (AISI TYPE 310) OR 18-8 MO. (AISI TYPE 316)

FIGURE 7—Typical Application of Stainless-Steel Facing to Flange Gasket Surfaces.

complished by careful oxy-acetylene application of low-zinc bronze in sufficient thickness to allow final machining with a minimum bronze thickness of ⅛-inch at the tube holes. Chamfering is omitted. The tube, when expanded, seals off the underlying steel from contact with the electrolyte (see Figure 3-A).

Based on 2-inch total thickness, the cost of both tube sheets clad by this method will run close to 90 cents per square foot of exchanger surface (based on 1-inch-od, 16-foot-long tubes on 1¼-inch square pitch). Solid naval bronze would cost 70 cents under the same conditions.

7). Monel-clad steel plates of the mill-clad variety have also been successfully used, although the extent of usage has been insufficient to determine service temperature limits (see Figure 3-C). Cost is usually 68 cents per square foot of exchanger surface, with conditions the same as in case (6) above.

8). As another successful alternate, naval-bronze plates have been furnace-silver-soldered to steel sheets, as shown in Figure 3-B. This work is being done in a Gulf Coast exchanger-maintenance shop at a cost of 69 cents, which compares favorably with monel mill cladding [see case (7)] and can be produced with very favorable delivery time. This type of sheet has been used with gratifying results when metal temperatures are 400° F. or lower. High temperatures are associated with excessive differential expansion and subsequent failure of the bond between bronze and steel.

9). Monel-clad by welding. The method which has been used most extensively consists of depositing monel on steel tube sheets, using welding as a means of applying monel. The steel tube sheet is prepared by machining the sheet to a true plane, cutting all grooves for gaskets and pass ribs ¼-inch wider and ⅛-inch deeper than required in the finished tube sheet. Usually three passes of weld metal are applied which are of sufficient thickness to allow ⅛-inch of monel over all surfaces after machining.

To facilitate good penetration and a high-quality weld, it has been found desirable to apply the first pass using pure nickel electrodes—the two subsequent passes using monel electrodes.

The tube sheet is machined to a true surface, and any defects are repaired before drilling the tube holes. Tube sheets prepared by this method are less costly than non-ferrous sheets of equal design strength, and will withstand more retubings without distortion than non-ferrous tube sheets.

Tube Sheets for Hydrocarbon Service—For all except the most severely corrosive hydrocarbon service, plain carbon-steel tube sheets are used with appropriate corrosion allowances applied to the thickness. Tongue-and-groove gasket joints are used with the groove in the tube sheet. The gasket grooves usually retain a good bottom surface because of the protection afforded them by the walls of the groove. Occasionally, however, they become damaged by corrosion or abuse, and repair is necessary. Remachining is possible without removal of the tube sheets from the bundle, and subsequent retubing by the use of a horizontal boring mill which is sized to handle the largest bundle in the refinery.

When bundles are retubed and rebuilt, the tube sheets are inspected to determine if remachining of gasket surfaces is required. If refinishing is necessary, these surfaces are remachined in an alloy-weld overlay, usually of 25-20 AISI (American Iron and Steel Institute) type No. 310 chrome-nickel, or chrome-nickel-molybdenum AISI type No. 316 stainless steel. Both of these metals are well adapted to high-temperature sulfur corrosion, with the latter being also applicable where organic acids are bothersome. Monel, as well as type No. 316 stainless steel, has been used for resistance to hydrochloric-acid corrosion (see Figures 5-A and B).

Completely new exchangers or bundles for services involving unusually corrosive conditions are sometimes equipped with full alloy wash-welded clad tube sheets. The chrome-nickel stainless steels are well adapted to this kind of work. The most frequent choice is 25-20 AISI type No. 310 because of its excellent corrosion resistance to most refinery corrosives, and because of its excellent machinability. Figure 6 illustrates the excellent condition of a 25-20 full-face cladding after a year of service as a stabilizer feed preheater where organic-acid corrosion has been very troublesome.

Bundle Baffling—As in the case of tube sheets and tubes, replacement of transverse baffling cannot be made without complete retubing of the bundle. This

involves an expense far beyond the cost of the baffles alone.

Carbon steel is ordinarily used, provided reasonable thickness of from ¼ to ½-inch are sufficient for at least the life of the tubes at the corrosion rate involved.

The baffles, although exposed to the same fluid as the outside of the tubes, are ordinarily corroded at a more rapid rate. Both surfaces of the baffles are exposed and affected, whereas only the outside of the tube is exposed; also the baffle temperature more nearly approaches the shell-side fluid temperature. When the heating medium is on the shell side and is corrosive at high temperatures, the penetration rate for the baffles will generally be greater than the penetration rate for the tubes when the materials are alike.

Both 18-8 stainless and 5-percent-chrome steels have been used economically where heavy cracked distillate recycle is used on the shell side of preheaters and where high-temperature sulfur corrosion is a factor. Bronze has also been used to resist hydrochloric-acid attack in virgin naphtha condensers.

Shell and Shell Cover—Although welded alloy-steel shells are available, Smiths Bluff refinery has used plain carbon steel to date. Corrosion allowances up to ⅛ inch have been applied to the thickness. Greater allowances would ordinarily be of no value, as the exchanger efficiency would be reduced by bypassing to such an extent that full use of the corrosion allowance could seldom be realized.

Localized alloy wash-welding with 25-20 chrome-nickel rod has been resorted to in a few cases. The cost of deposited metal is such as to make it an undesirable method of large-scale protection. The use of alloy strip lining has been confined to more or less emergency repairs. Such liners utilize 3- or 4-inch wide strips of 12 to 14-gauge alloy steel, such as 18-8 molybdenum type No. 316, or 11½- to 13-percent chrome type No. 410 (maximum carbon, 0.08 percent), applied to the shell by electric welding at the edges of the strip with 25-20 chrome-nickel welding rod. Although costs of from $8 to $14 per square foot are possible, the method is not favored because of the possibility of liner failure and subsequent interference with free passage of the transverse baffles and floating tube sheet when removing the tube bundle.

Shell flanges are used with tongue-and-groove gasket-joint construction. Mechanical handling, as well as corrosion, often damages the gasket seating surface. Remachining is accomplished by use of a portable facing tool after the surface has been built up by welding. Costs are usually in the neighborhood of from $60 to $70 per foot of diameter; 25-20 chrome-nickel or 18-8 molybdenum stainless-steel welding rod is always used instead of carbon steel for this work, because the material cost is only a minor part of the total job cost. Subsequent corrosion troubles are thereby eliminated.

Figure 7 illustrates the application of alloy to gasket surfaces.

Channel, Channel Cover, and Floating Tube-Sheet Cover—These parts are all easily replaceable whenever the exchanger is out of service; therefore, the economics of alloy applications are to be based only on replacement cost of the subject part.

When necessary or economical, these parts are equipped with alloy-faced surfaces for the circular gaskets, as well as the edges of baffles for baffle gasketing. Other areas are commonly protected by strip lining, with materials appropriate for the service.

Summary

To summarize, it should be recognized that the factors which must be considered in heat-exchanger corrosion problems are many and varied. In many cases it is almost impossible to evaluate some of them accurately. There are many corrosives involved; and, although it is possible to determine accurate corrosion rates under controlled laboratory conditions, it is seldom possible to predict the behavior of these corrosives accurately under field conditions. Such factors as the presence of unidentified corrosives; variations in pressure, temperature, and velocity; variations in product specifications; as well as changes in crudes or charging stocks, serve only to contribute to the complexity of the problem.

In the absence of economical means for the removal or neutralization of corrosives, the use of alloys will continue to be economically attractive. The development of new alloys must be followed in the interests of keeping material costs to a minimum consistent with required service life. Careful consideration of service conditions and proper material specifications will substantially reduce the petroleum refiner's heat-exchanger corrosion problems.

NOTE

The above paper was presented to a group session on corrosion during the 13th mid-year meeting of the American Petroleum Institute's Division of Refining in Philadelphia, May, 1948.

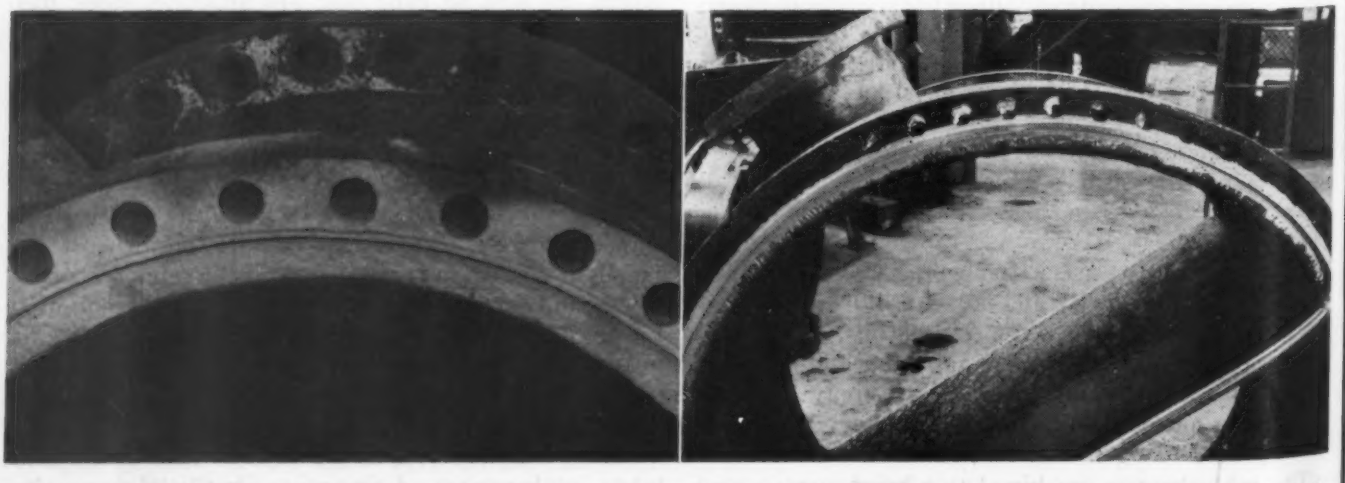


FIGURE 8—A (at Left) Shows a Badly Corroded Gasket Surface on a Channel. B (at Right) Shows the Same Channel After Weld Overlay With 25-20 Chrome-Nickel Stainless Steel Welding Rod and Re-Machining.

Welding Dissimilar Metals

BASIC PRINCIPLES OF THIS IMPORTANT PRODUCTION TECHNIQUE ARE OUTLINED

D. R. KASANOF
Tempil° Corp., New York

WELDING dissimilar metals is an important production technique. It ranges from the assembling of large structures like pressure vessels down to joining the shank and drill portion of a twist drill.

Different portions of a unit frequently require different properties which one metal cannot furnish. For example, when part of a piping system operates at a much higher temperature than the remainder, special alloy steel may be specified for the "hot" portion and less expensive low alloy steel for the "cold" section. Similarly, the inside of a pressure vessel may be subject to severe corrosion that demands a corrosion resistant alloy, whereas plain carbon steel may be satisfactory for the outside of the vessel.[1] Hard facing, too, involves the welding of dissimilar metals. Economy therefore dictates the use of the least expensive materials, but only if the dissimilar metals can be welded satisfactorily to produce joints which are sound, strong and tough, free from cracks and from other defects which may cause early failure in service.

Welding of dissimilar metals may be divided into three classes. In the first group the compositions are all iron base (ferrous). They may vary only slightly in composition, as when joining plain carbon to carbon molybdenum steel (the difference consisting of the ½ percent moly in the carbon molybdenum steel). On the other hand the base metals may vary considerably as when joining a plain carbon pipe to 12 percent chromium steel or when joining low alloy steel to high tungsten tool steel.

Non-Ferrous Alloys

The second category covers the union of various alloys of non-ferrous composition, as well as the pure metals of the non-ferrous group which includes copper, aluminum, magnesium, nickel, zinc, etc. Special alloys like Stellite, Hastelloy and Inconel would also fall into this classification.

The third class embraces the joining of ferrous to non-ferrous metals, as for instance the welding of non-ferrous Monel piping to a steel vessel.

Where economy demands the choice of dissimilar compositions a thorough knowledge of actual service conditions, particularly temperature, stress, abrasion and corrosion, is essential in order to insure that satisfactory materials are selected.

Equally important is choice of the proper welding method and selection of the correct electrode. The weldrod when diluted with the base metal during the welding operation must produce weld metal of desirable properties. In some cases the rod may be similar to one of the compositions being joined; in other cases it is entirely different in composition from either base metal.

Another factor to be considered is the effect of welding temperatures on the "heat-affected" zone in each base metal. This zone is usually of non-uniform grain size after welding. The degree of residual stress in the different metals will also vary considerably. In some cases it is possible to influence the properties of the heat-affected zone by changes in welding procedure—thus higher preheat temperatures will prolong the duration of the various temperature zones and lessen the danger of cracking.[2]

Heat Treating the Welded Joint

Similarly one must not overlook the possible need for heat treating the welded joint. Treatments will vary from no heat treatment or merely low temperature stress relief to full heat treatment.

Since each metal combination presents a separate problem, metallurgical knowledge and experience should dictate not only the choice of the prescribed welding method but also the exact preheat and post-heat procedures to be followed. Some general rules for steels are listed below:

1) Almost any two ferrous metals (steels) may be joined with 25 percent chrome-20 percent nickel electrodes, since the latter composition can withstand considerable dilution without affecting weld metal properties.
2) When welding steels, the weldrod may be of the lower alloy composition of the two base metals, provided it yields a strong tough weld.
3) When joining pearlitic or ferritic steel to an austenitic steel, use 25 percent chrome-20 percent nickel weldrods.
4) Preheat is of the greatest importance and should always be used wherever dissimilar metals are welded. The minimum should be 200° F. but it should never be less than that required for the most delicate of the two steels to be joined.

The welding of dissimilar metals[3] is so complex a subject that it is not possible to deal with it completely in this brief summary. The references will be helpful to those seeking further information.

REFERENCES

[1] "The Fabrication of Clad Steels," Tempil° Topic, Vol. 2, No. 5, Nov. 1, 1947.
[2] See Tempil° Preheating Chart listing recommended preheat for 79 commercial metals and alloys.
[3] "Welding of Dissimilar Metals," Spraragen and Rosenthal, American Welding Society Journal Supplement, Feb. 1945, pages 65S to 85S.
[4] "Welding of Dissimilar Metals," Spraragen and Rosenthal, American Welding Society JPournal Supplement, Feb. 1945, pages 65S to 85S.

Nomograph for Equilibrium Flash Calculations

EDWARD G. SCHEIBEL,
Hoffmann-LaRoche, Inc., Nutley, N. J.

THE calculation of the equilibrium flash for a muli-component mixture is carried out by a trial and error method in which the ratio of liquid to vapor is assumed and checked by determining the sum of all the individual components in the liquid at this ratio. The equation giving the moles of each component in the liquid can be derived as follows:

$$l = \frac{f}{1 + \frac{VK}{L}}$$

where f = moles of the component in the total mixture
V = total moles of vapor
L = total moles of liquid
K = K-value of the component at the temperature and pressure of the equilibrium flash.

Recently Poettmann and Rice[1] have proposed nomographs for carrying out this calculation graphically. However their charts are rather complicated to read or construct because of the muliplicity of the scale ranges and they require two settings to carry out one calculation. The nomograph presented in this work is simpler to use, requiring only a single setting for a calculation and the nature of the scales is such that any numerical value can be easily applied in the calculation. This nomograph also eliminates the necessity of calculating the fractional composition of the total mixture because it can be applied directly to the actual quantities present in the mixture.

The nomograph shown in Figure 1 is constructed by calibrating a vertical scale according to a reciprocal relationship and a uniform horizontal scale. The left hand scale is the ratio of $\frac{L}{V}$ and the right hand scale is used to construct the grid with the vertical scale as shown. Then by placing a straight edge so it passes through the value of $\frac{L}{V}$ on the left horizontal scale and the value of f on the vertical scale, the value of l is obtained by intersection of this line with the proper value of K on the abscissa of the grid as read on the ordinate which has the same calibration as the vertical scale.

Thus any scale factor can be applied to the ordinate and while the grid is calibrated for values of f from 1 to 10, a scale factor of 10, 100 or 1/10 can easily be applied and the same factor is used in reading off the value of l. The vertical f-scale is calibrated to 100 so the values that fall outside the grid can be brought down on the grid by using the 10 to 100 scale with the proper scale factor.

"Of Sufficient Accuracy"

Also if greater accuracy is desired than can be obtained from the grid in the region of high values of f such as 5 to 10 a scale factor of 2 or 1/2 can be used for the numerical values although this is not so convenient. In general the entire range of the nomograph given will be of sufficient accuracy for most industrial calculation and these unusual scale factors need be used only in very special cases where high accuracy of a particular value is required.

The horizontal scale also lends itself very readily to the use of different scale factors and it must be remembered that both the $\frac{L}{V}$ and K scales are then used with the same scale factor. The lower horizontal line shows the values on the horizontal scale that must be used when the greater fraction of the feed vapor is so that $\frac{L}{V}$ is less than unity. For K-values greater than those shown on the particular scales, a scale factor of 10 or 100 maye be applied to the horizontal scale but in this case the proper point on the $\frac{L}{V}$ scale must be used which corresponds to this same scale factor. As for example at a K-value of 25 and an $\frac{L}{V}$ of 5 the graphical calculation can be made by using the value of $K = 2.5$ and the value of $\frac{L}{V} = 0.5$ on the nomograph.

As an illustration of the use of this nomograph the equilibrium flash calculation described in a previous paper[2] has been worked out by means of this nomograph. Only the final solution is shown in the following table.

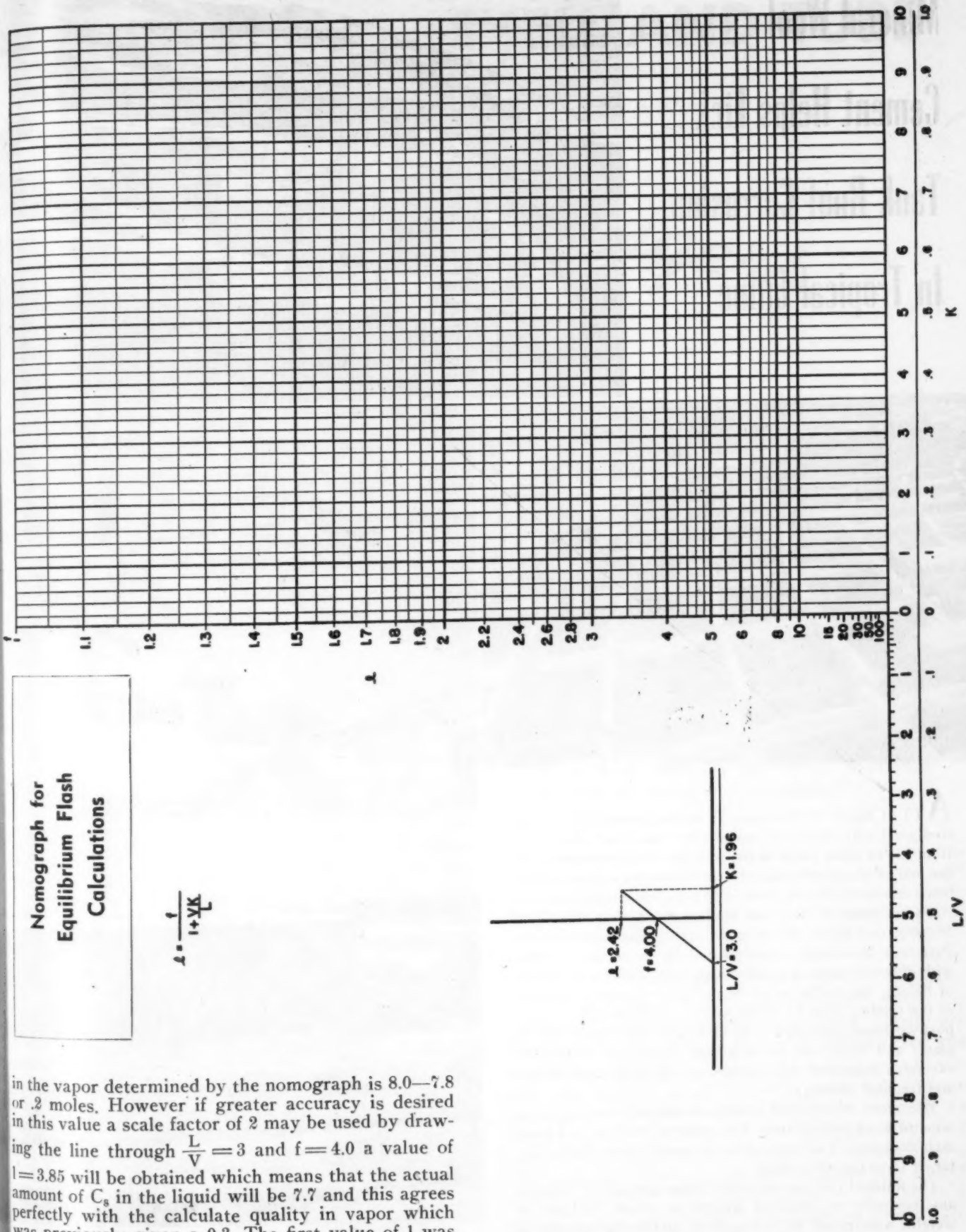
	f m/hr.	K 220° F. 100 Lb.	Assume $\frac{L}{V} = 3$ l m/hr.
C_3	1.0	4.5	.4
C_4	40.0	1.96	24.2
C_5	23.0	.93	17.5
C_6	16.0	.45	14.0
C_7	12.0	.21	11.2
C_8	8.0	.105	7.8
	100.0	....	75.1

$\frac{V}{L} = 24.9$

$\frac{L}{V} = 3.01$

The total value of L determined from the nomograph compares favorably with the value of 75.0 calculated previously and the agreement of all values with the calculated ones will be seen to be within the accuracy of reading the nomograph. It should be noted that the previous calculation gave values of v (the moles in the vapor) which are equal to f—l. A similar nomograph could be constructed which would allow the calculation of v instead of l however this nomograph would have reciprocal scales for $\frac{L}{V}$ and K and consequently would not be as simple to construct and use. The vertical scales in this case would be the same.

It should also be noted that the amount of C_8



in the vapor determined by the nomograph is 8.0—7.8 or .2 moles. However if greater accuracy is desired in this value a scale factor of 2 may be used by drawing the line through $\frac{L}{V} = 3$ and $f = 4.0$ a value of $l = 3.85$ will be obtained which means that the actual amount of C_s in the liquid will be 7.7 and this agrees perfectly with the calculate quality in vapor which was previously given a 0.3. The first value of l was within the accuracy of reading the chart and the latter technique may be used in special cases where this accuracy is not considered sufficient.

Thus the present nomograph is simpler to construct and use than previous nomographs and gives values which agree very well with the calculated values and by the use of a proper scale factor any desired accuracy may be obtained within the limits of reading the chart.

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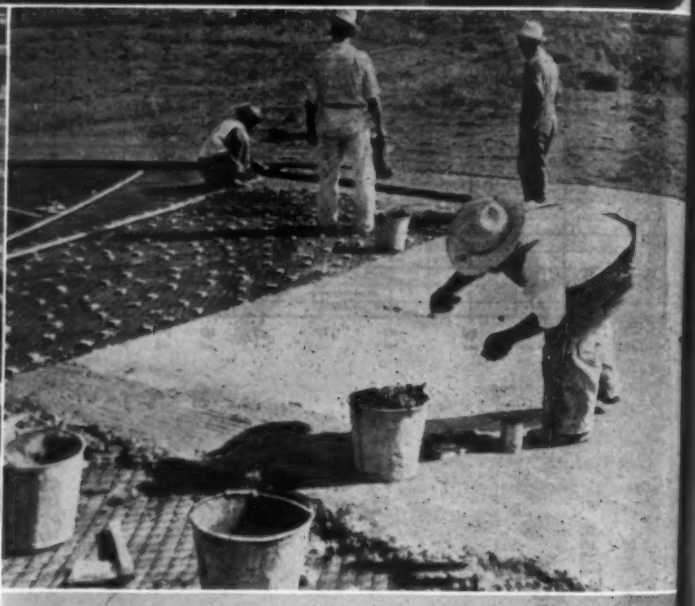
Mineral Wool Cement Helps Lick Tank Roof Corrosion In Tropical Clime



ATTACKED on the inside by hydrogen-sulphide fumes combined with moist air, metal-plate tank-roofs last only from six to eight years in the tropical Gulf Coast area. At the end of about six years it is necessary to re-roof petroleum storage tanks—a costly and time consuming job.

The problem in this case applied to not less than fifty 55,000-barrel tanks. When confronted with this problem, Petroleos Mexicanos experimented for more than a year with different types of roofing materials, with the objective of licking the corrosion problem. Other features required of the roofing were 1) it had to be rugged enough to support workmen; 2) it had to be no heavier than ⅜-inch steel plate; and 3) it had to be elastic enough to withstand excessive expansion and contraction caused by tropical sun and frequent showers.

The most economical roofing developed was one of a mineral wool cement base. It is poured in place to a two-inch thickness. The reinforcing shown in photo, right center, is 12-gauge wire mesh.

The finished roof has sufficient beam-strength to support any normally encountered weight or shock, is light in weight, waterproof, lightning-proof, and elastic enough to withstand expansion and contraction conditions. The new roof can be expected to outlive metal roofing by at least four times and costs no more.

A major advantage stems from the insulating qualities of the new roofing material. These insure maintenance of more uniform temperature inside the tank and thus reduce losses by evaporation, wind drift, and breathing.

Photo at top of page shows oil tank roof in Mexico virtually destroyed by the constant attack by corrosive gases, particularly H_2S.

Center photo, left, shows wooden forms put up prior to laying the mineral-wool base cement.

Center photo, right, mineral-wool base cement being poured in place to a two-inch thickness. Reinforcing is 12-gage wire mesh.

Lower photo, oil tank on which new roof has been completed.

SHELL AND TUBE Heat Exchangers

FRANK L. RUBIN
Heat Exchanger Division,
The Lummus Company, New York

SHELL and tube heat exchangers constitute the bulk of heat recovery equipment employed in hydrocarbon processing plants. In the technical literature and in the catalogues of exchanger manufacturers, a sizeable volume of information on the design, fabrication, and operation of such equipment has appeared. Because of the great variety of applications for heat exchange equipment, an involved system of nomenclature has developed which describes exchange apparatus in terms of its use rather than in terms of the actual equipment design details.The author herein clarifies much of this nomenclature by explaining its origin, and then goes on to discuss some of the basic reasoning that serves to set the selection and design of such equipment.

THE transfer of energy in the form of heat is an integral part of most of the operations of chemical engineering. Industrially the transfer of heat by convection is generally carried out in shell and tube heat exchangers. Pipe coils and double pipe exchangers are used in some instances.

The nomenclature adhered to by the manufacturers and users of heat transfer equipment is such that different terms are used to describe units, which differ not in their mechanical details but only in their process applications. A brief discussion of this terminology follows.

If water is used to cool a process fluid, the unit is called a *cooler*. If steam is employed to heat a water or a process stream, the term *heater* is applicable. When heat is transferred between two process fluids or two water streams the term *exchanger* is relevant. A *reboiler* evaporates a process fluid. A *condenser* is a water cooled unit, which condenses a vapor. (If a unit condenses a process fluid by the removal of heat to another process fluid, the designation of *exchanger* applies.) An *evaporator* generates steam with the use of steam, as the heating medium. A *steam generator* produces steam from water, when the heating medium is a process fluid.

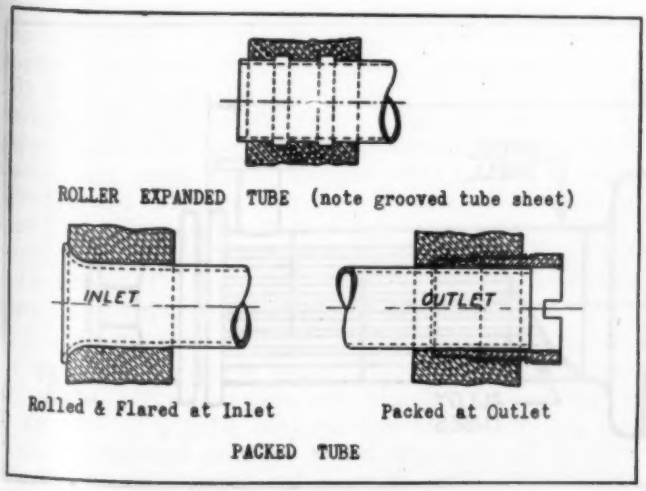


FIGURE 1
Usual Methods of Installing Tubes

In power plants a shell and tube unit, which condenses turbine exhaust steam, is called a *surface condenser*. This terminology is used to differentiate a *surface condenser* from a *barometric condenser* in which steam is condensed by direct contact with a spray of water.

Exchanger Construction

Heat exchanger tubes are generally roller expanded into the tube sheets. Tube holes usually are $.008 \pm .003$ inch greater than the diameter of the tube. Two circular grooves 1/64-inch deep are cut into the inside surface of each tube hole. These grooves are parallel to the tube sheet surfaces. In the process of expanding the tube to fit the tube sheet opening, the tube metal is forced into these grooves. The tubes are thus strongly held in place and a tight seal is provided. The upper diagram of Figure 1 shows a tube, which has been roller expanded into a grooved tube sheet.

Surface condensers which are generally much larger than typical heat exchangers, and other steam condensers for low pressure service often have the individual tubes packed into one of the tube sheets. Figure 1 shows a common method of installing

packed tubes. The packed joint consists of a tube, a ferrule, which threads into the tube sheet at the outlet end, and packing to complete the joint. These tubes are readily replaceable and the packing permits expansion of the tube. Packed tube units are suitable only for low pressure service. The present tendency in power plants is to no longer make use of the packed tube. Roller expanded tubes and shell expansion joints are now being used on most of the present day surface condensers.

Tubes are generally spaced on a triangular or a square pitch. The use of square pitch permits the insertion of a bar or a scraper between the tubes to clean the outside of the tubes. This type of cleaning can not be carried out with tubes spaced on a close triangular pitch. However, the latter pitch permits the installation of more tubes in a given shell. The center to center distance (pitch) of tubes is generally maintained at 1.25 × tube o.d. with a minimum pitch equal to the outside diameter of the tube plus ¼ inch.

To obtain high tube side velocities and correspondingly high heat transfer rates, most exchangers are constructed with two or more tube side passes. Generally an even number of tube side passes is preferred, since the tube side piping is at one end of the exchanger and construction is simplified. The tube side fluid flows from this piping into that part of the exchanger known as the channel and thence into the tubes proper.

The shell side fluid enters the shell through an inlet nozzle and is directed by baffles so that the fluid crosses and recrosses the tubes. The heat transfer rate and the pressure drop on the shell side are controlled by adjusting the spacing (or pitch) and the shape of the baffles.

A channel is provided with a cover, which may be removed to permit inspection and cleaning of the inside of the tubes without disturbing the piping connections. The exchangers in Figures 2 and 3 are constructed with such channels.

A bonnet may be used in place of a channel as in Figures 2 and 4. (The exchanger in Figure 2 has a bonnet, which is labelled "alloy head.") A bonnet however, does not have a cover and is generally used for extremely clean tube side fluids or to keep initial costs down. When a bonnet is utilized the piping must be dismantled before the tubes become accessible.

Tubes

The available surface for heat transfer is measured at the outside of the tubes. The outside diameters of the standard tubes, which are available, are ¼, ⅜, ½, ⅝, ¾, ⅞, 1, 1¼, 1½, 2, and 2½ inches. The ¾ and 1-inch o.d. tubes are the most commonly used. The conventional practice is to regard the "surface" of a shell and tube unit as the external surface of the tubes for their entire length. All units for power plant installations, such as feed water heaters, and surface condensers, are rated in terms of "effective surface," i.e., the external tube surface between the tube sheets.

Smaller diameter tubes offer the advantages of higher heat transfer rates and greater surface in a given shell. When larger tubes are used, cleaning time is proportionately less since there are fewer tubes for a given surface and since the time to mechanically clean a tube is independent of the diameter. Mechanical tube cleaners for the larger tubes are more powerful and hence more effective in removing heavy deposits. The 1¼-inch and larger tubes are used with fluids which foul excessively. Larger tubes can be cleaned at greater intervals, since there is less likelihood that they will become plugged by deposits of fouled material.

The thickness of tubes is specified in Birmingham

TABLE 1
Shell Sizes

NOMINAL SHELL SIZE (Inches)	Material	Minimum Wall Thickness (Inches)
6	Standard Pipe	0.258
8	Standard Pipe	0.322
10	Standard Pipe	0.365
12	Standard Pipe	0.375
14	Seamless Pipe	0.375
16	Seamless Pipe	0.375
18	Seamless Pipe	0.375
20	Seamless Pipe	0.375
22	Seamless Pipe	0.375
24	Seamless Pipe	0.375
26	Welded Plate	5/16
28	Welded Plate	5/16
30	Welded Plate	5/16
32	Welded Plate	11/32
34	Welded Plate	11/32
36	Welded Plate	11/32
38	Welded Plate	11/32
40	Welded Plate	½
43	Welded Plate	½

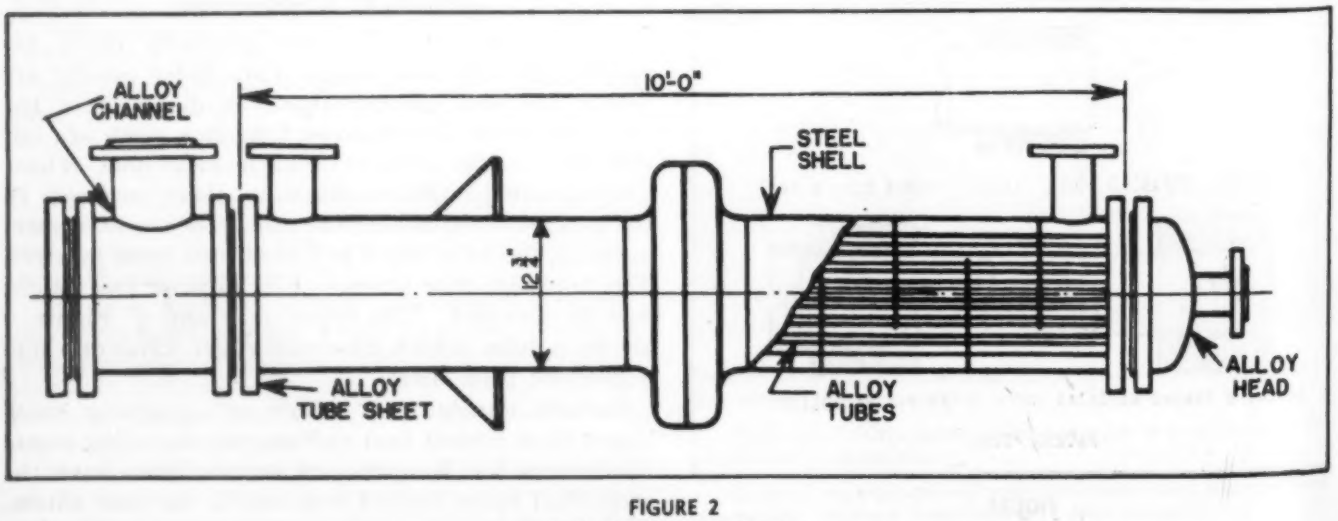


FIGURE 2
Fixed Tube Sheet Exchanger

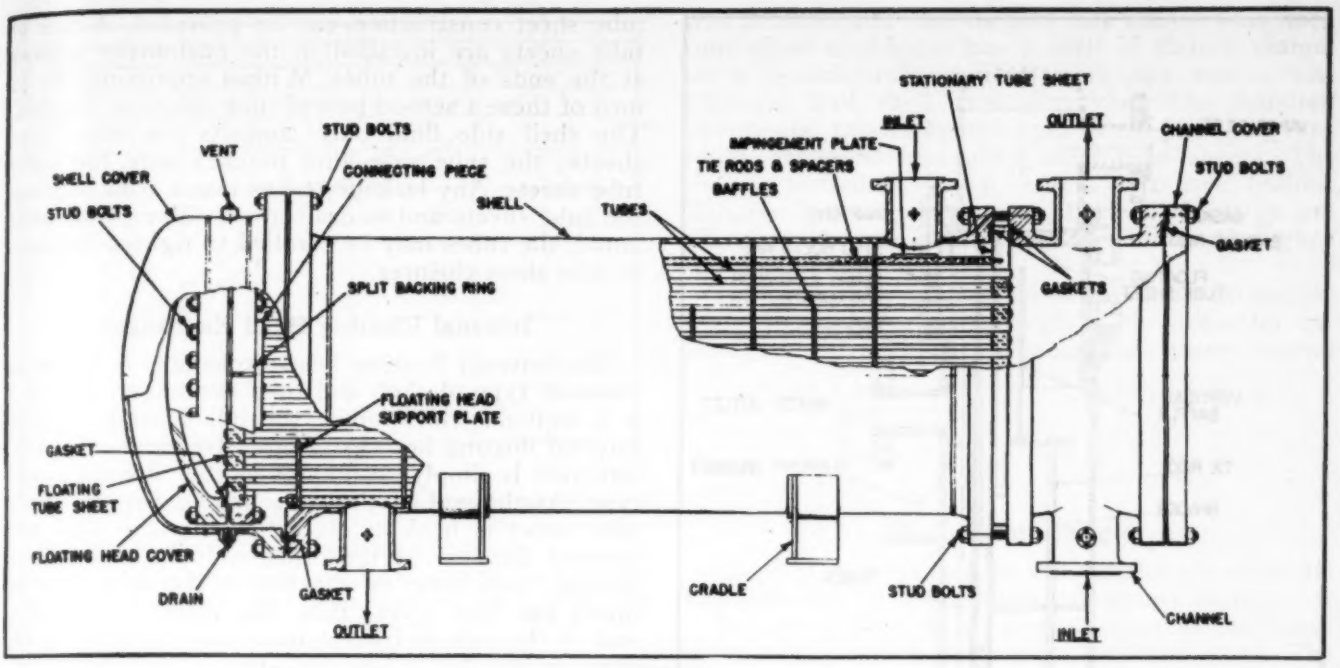


FIGURE 3
Floating Head Exchanger

wire gauge units. Nonferrous tubes are generally 16 or 18 Bwg. (0.065 or 0.049-inch wall thickness) : steel tubes are often 12 or 14 Bwg. (0.109 or .083-inch thick).

The standard over-all tube lengths of the Tubular Exchanger Manufacturer's Association[8] are 8, 12, 16, and 20 feet. The 16-foot over-all length is the most commonly used, particularly in the petroleum industry.

Shells

The "shell size" of a heat exchanger refers to the shell diameter. Tabe 1 lists the nominal shell sizes, shell material, and minimum wall thicknesses, which are generally employed. The larger units, which are normally fabricated of welded plate, have an inside diameter which is one inch less than the nominal size.

Materials of Construction

Exchangers are fabricated of carbon steel throughout, when process conditions permit. This construction is the most economical. The use of water as a cooling medium generally necessitates the use of copper alloys and cast iron. The cooling water usually flows through the tubes. For fresh and salt water service admiralty metal tubes, tube sheets of naval rolled brass, and cast iron channels and floating head covers are used. Other copper alloys may be substituted and castings may be of brass rather than of cast iron. For service at high pressures and temperatures cupro-nickel tubes are generally used with steel tube sheets. On occasion channels and tube sheets may be of cupro-nickel.

Special alloys are used as required for process conditions. When a single metal will not resist corrosion by the shell and tube side fluids, bimetal tubes composed of a tube core of one metal and an external surface of another metal are used. Clad tube sheets are often installed in units with such tubes. As an economy measure shells, covers, and tube sheets may be fabricated of carbon steel and clad with a lining of the metal, which is corrosion resistant to the shell side fluid.

TABLE 2
Relative Shop Costs of the Exchanger in Figure 3

TUBE SIDE METAL	Relative Cost
Steel	1.00
Aluminum 3-S	1.29
Copper	1.33
Silicon Bronzes (copper tubes)	1.35
70-30 Cupro-nickel	1.51
Stainless Steel-304	2.00
Monel	2.09
Stainless Steel-347	2.17
Nickel	2.26
Stainless Steel-316	2.34
Inconel	2.34

The Fixed Tube Sheet Exchanger

The fixed tube sheet exchanger is the simplest and least expensive type of shell and tube exchanger. When fabricated of carbon steel a piece of standard pipe is welded to two rolled steel plates, known as tube sheets. (This construction eliminates the need for gasketed joints on the shell side.) Carbon steel tubes are inserted through holes drilled in the tube sheets and baffles. The tube ends are roller expanded into the tube sheets. A bonnet and return cover complete the unit, when an even number of tube side passes are utilized. Fixed tube sheet exchangers readily can be built with an odd number of tube side passes; in this event a channel or bonnet replaces the return cover.

Unavoidable temperatures differences between the exchanger fluids cause the tubes and the shell to expand differentially. The temperature difference may be sufficiently large to cause roller expanded tubes to be pulled from the tube sheets. To prevent such a condition a diaphragm type of expansion joint is often built into the shell. (The use of packed tubes eliminates the need for an expansion joint).

Fixed tube sheet units may be constructed of metals which will not permit the welding of the tube sheets to the shell. In this event it becomes

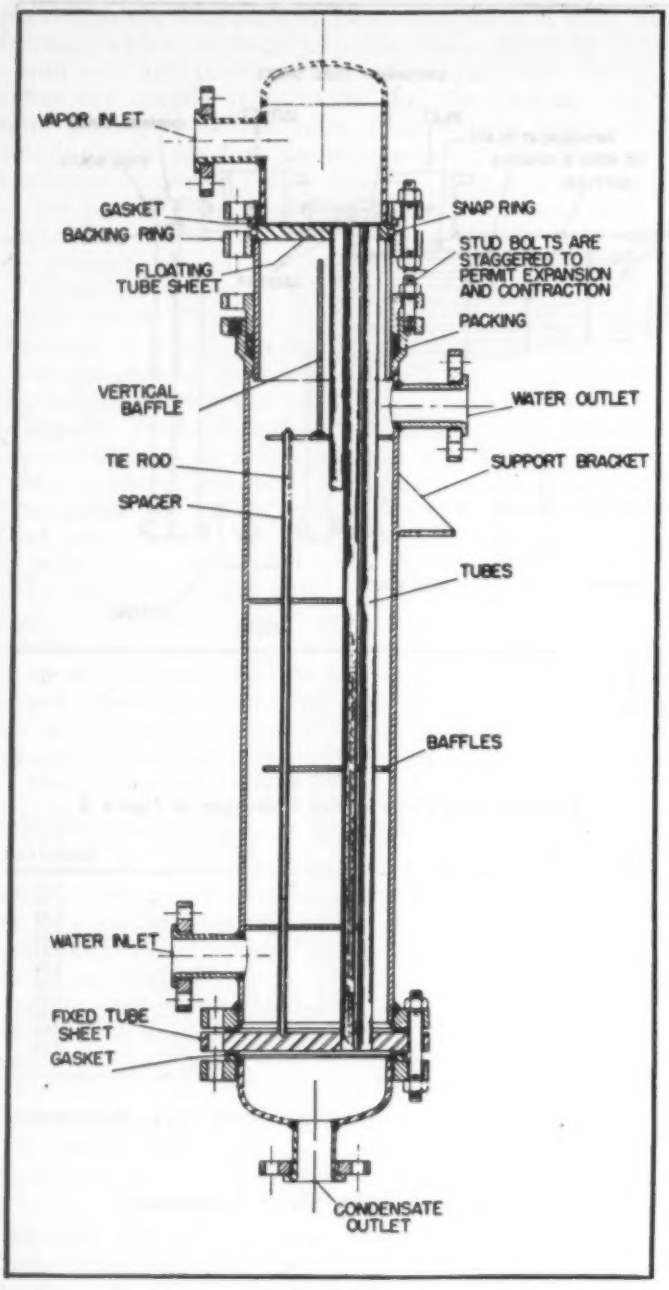


FIGURE 4
Packed Floating Head Exchanger

necessary to provide flanges, which are welded to the shell. The tube sheets are fixed in place by means of collar bolts to these flanges. Gaskets are placed between tube sheets and flanges. The tube side channel and return cover are then bolted to these flanges.

Figure 2 shows a fixed tube sheet exchanger with an expansion joint. This exchanger is designed for vertical installation with a single pass on the tube side and a single pass on the shell side. The unit is provided with a channel at the upper end and a bonnet at the lower end.

The tube bundle of a fixed tube sheet exchanger is not removable. This construction is used, when the shell side fluid is quite clean or when chemical cleaning can be utilized. Tubes are spaced on triangular pitch since there is no need to provide cleaning lanes about the outside of the tubes.

When it becomes necessary to prevent any possible mixing of the shell and tube side fluids, a double tube sheet construction can be provided. A pair of tube sheets are installed in the customary manner at the ends of the tubes. Within approximately ½ inch of these a second pair of tube sheets is installed. The shell side fluid only contacts the inner tube sheets; the tube side fluid touches only the outer tube sheets. Any leakage passes into a zone between the tube sheets and is drained off. When leakage is noted, the tubes may be rerolled to tighten the tube to tube sheet closures.

Internal Floating Head Exchanger

The internal floating head exchanger is the most common type of shell and tube exchanger. Figure 3 is a sectional elevation of the full floating head or internal floating head exchanger. Generally this construction is simply designated as the "floating head" type. At the end of the tube bundle the stationary tube sheet is held in place between the shell and channel flanges. At the other end of the bundle a floating head cover is attached to the tube sheet to direct the flow of the tube side fluid. The floating end of the unit is free to move and differential expansion between tubes and shell is permitted. The tube bundle can be removed from the shell to permit inspection and cleaning of the external surface of the tubes. In order to remove the bundle it is necessary to remove the shell cover, the floating head cover, and the channel. The inside of the tubes may be cleaned with the bundle in place within the shell. To make the inside of the tubes accessible the shell cover, floating head cover, and the channel cover must be removed.

Floating head units are generally constructed with an even number of tube side passes. This is done to maintain a simple floating head construction. The use of an odd number of passes necessitates the use of a "slip tube" which passes from floating head through the shell cover. A fine machine finish and special packing are required at this shell cover joint. Slip tube construction is not suitable for high pressure installations nor for volatile, inflammable fluids on the shell side.

U-Tube or Hairpin Tube Exchanger

The U-tube construction permits each tube to expand and contract independently of the other tubes. There are no internal gaskets and only one tube sheet is required. The tube bundle is removable. Obviously a U-tube unit must have an even number of tube side passes.

In high pressure installations a substantial economy is affected by the elimination of a tube sheet, the floating head cover, and flanges for bolting the shell cover to the shell. (The shell cover is always welded to the shell when U-tube construction is employed.)

Tubes bent on a sharp radius undergo severe thinning of the tube wall. To overcome this, tubes with dual gauge thickness are often used. These tubes are manufactured with a heavier wall section at the center of the tube. After bending, such tubes are no thinner at the center, than at the ends. The U-tube construction is generally employed when the tube side is quite clean. When fouling occurs and chemical cleaning is not effective special mechanical tube cleaners, which can navigate the bends, must be used. These cleaners can not navigate bends made on a short radius. Therefore it is necessary to install fewer U-tubes in a unit, which must be designed for

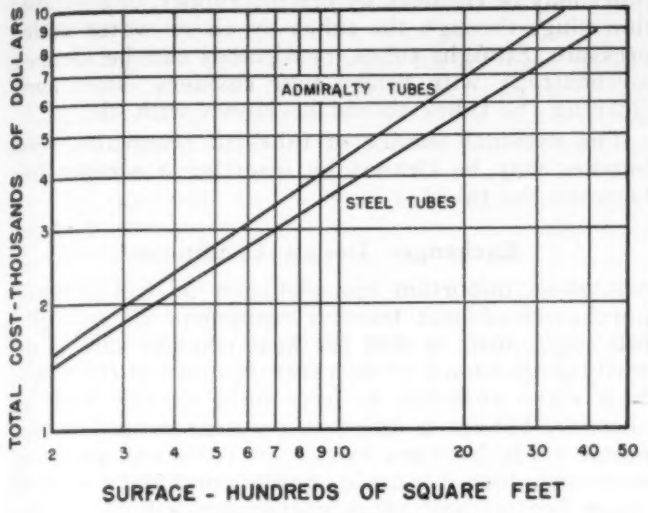


FIGURE 5—EXCHANGER COSTS

Internal floating head construction: Admiralty tubes, 16 feet long—cast iron channels and floating head covers, brass tube sheets, carbon steel baffles and shells, 150 psi. design pressure. Steel tubes, 16 feet long—carbon steel throughout, 150 psi. design pressure.

cleaning with a mechanical tube cleaner. In straight tube exchangers any tube can be easily replaced. Only those tubes at the outside of the U-tube bundle can be readily removed or replaced. Tubes within the bundle do not become accessible until the outer tubes have been removed.

Packed Floating Head Exchanger

The packed floating head exchanger construction, (Figure 4) provides the least expensive type of removable bundle. Note that only a limited amount of differential expansion between the tubes and the shell is permited by the packed joint. An excessive amount of expansion would cause leakage of the shell side fluid. Contraction is limited by the packing material.

The illustrated unit is a vertical condenser with the condensing vapor flowing through the tubes. A vertical condenser with the vapor flowing down through the tubes is very effective in producing subcooling of the condensate. It should be noted that the type of packed expansion joint shown does not permit the location of the shell side outlet nozzle at the end of the tube bundle. A vertical baffle has been installed in order to force the shell side cooling water to flow across the tubes for their entire length.

The packed head exchanger is not suitable for use with volatile inflammable fluids nor for high pressures on the shell side.

Costs of Heat Exchangers

The direct relationship for a specific type of exchanger construction between total cost and surface can be represented by a straight line on a log-log plot. The approximate costs in the spring of 1947 of full floating head exchangers with tubes 16 feet long are shown in Figure 5. The steel tube units are constructed of carbon steel throughout. The exchangers with admiralty tubes have cast iron channels and floating head covers, brass tube sheets, and carbon steel baffles and shells.

Recently a manufacturer of heat exchangers published an advertisement showing the relative shop costs of the exchanger in Figure 2, when the unit was fabricated of various tube side alloys. This fixed tube sheet exchanger has a shell of 12-inch diameter x ⅜-inch wall seamless steel pipe with a diaphragm type shell expansion joint. One hundred twenty-six tubes, ¾-inch o.d. x 10-feet long are roller expanded into alloy steel tube sheets. The shell is baffled on 6-inch centers with steel baffles. Relative costs are shown in Table 2. In large exchangers the ratio of alloy cost to steel cost is higher than shown in this table.

Tube length is a factor in determining exchanger costs. The relative costs as given by Sieder for exchangers with varying tube lengths are shown below:

Tube Length (feet)	Relative Cost.
8	1.3
12	1.1
16	1.0
20	0.95

Mechanical Design

The design pressures for exchangers are often 75, 150, 300, 450, or 600 pounds per square inch.

The use of these design pressures permits the manufacturer to prepare units with standard parts. The TEMA Standards give flange dimensions for 150, 300, and 450 pounds per square inch design pressures. Units built with such flanges can readily be furnished with some replacement parts by either the original manufacturer or by others.

The API-ASME Code[1] is practically the universal standard for the construction of exchangers for the petroleum industry. Many units for chemical plant installation are built in compliance with this code. The ASME Code[2] is adhered to for power plant construction and for some chemical plant installations. The latter code is more severe. It employs a safety factor of five (as against the API-ASME value of four) and requires an hydraulic pressure test at double the design pressure.

The TEMA Standards[5] are often followed in conjunction with one of the above codes. These standards in the main are supplementary to the API-ASME Code and cover details such as baffle clearance, tube sheet design, flange design, standard shell sizes and design pressures, fouling factors, and temperature difference correction factors. The HEI Standards[6] are universally adhered to in the design of surface condensers.

Installation of Exchangers

Exchangers almost invariably are mounted horizontally or vertically. The former position is more common. All straight tube exchangers require a clear space approximately equal to the tube length at the channel end. This provision is made so that new tubes may be inserted to replace corroded tubes. A free space abviously must be provided for removable tube bundles.

The weights fo rempty tube bundles, assembled exchangers, and flooded assembled exchangers are presented in Figure 6. These curves are approximately correct for exchangers constructed with 16-foot tubes of other tube sizes and metals. Of course the structural supports must be capable of supporting the flooded exchanger. The tube bundle of the 36-inch exchanger (the maximum allowable size in many refineries) weighs approximately four tons. These curves are for 16-gauge tubes and often tubes with a heavier wall thickness are empoyed. In re-

fineries an overhead crane is generally available to handle heavy tube bundles. In some chemical plants a three or four-ton exchanger bundle would present quite a problem, whenever cleaning of the tube bundle would be necessary. In some instances the weight of the tube bundle becomes the limiting factor in the design of the exchanger.

Exchanger shells should be mounted, as designed, in a true horizontal or vertical plane. Piping should be properly supported so that excessive strains are not placed upon the nozzles of the shell and tube unit. The necessary expansion joints should be provided in the piping. The cradle support at the shell cover end of a horizontal exchanger is provided with slotted holes. The nuts of the foundation bolts passing through these slots should not be tightened, as the slots are provided to permit thermal expansion and contraction of the unit.

Operation of Exchangers

All bolting should be taken up evenly. All joints must be made tight; for units operated under vacuum this is of great importance. The unit should be hydrostatically tested on the shell and tube sides to the appropriate test pressures.

When operation starts, the unit should be fully vented. Continuous venting of steam heated units is desirable. The exact setting of the vent valve should be determined by the operator to permit maximum venting and minimum blow through. In starting up, the cooling fluid should be introduced first. When stopping operation, the hot fluid should be shut off first. (In units operating far below room temperature the reverse procedure should be followed.)

When a unit does not function properly one or a combination of the following conditions probably exist: 1) The unit is not properly vented. 2) Piping connections do not permit the design flows. 3) In units in which a vapor condenses, the drainer is not operating properly and tube surface is flooded by condensed medium. 4) The tube surface is dirty. 5) Piping or valves do not permit the proper flow of fluids.

Cleaning Exchanger Tubes

The solvent action of water or chemicals when effective, is the preferred type of cleaning. Chemical cleaning must be judiciously employed as the exchanger parts may be attacked. Petroleum fluids often deposit films which may be removed by treatment with patented cleansers. Water scale can often be removed with phosphate type cleansers. Brushing with a stiff wire brush will remove some deposits.

Soft slime deposits in straight tubes may be removed by driving rubber, or composition plugs through the tubes by air or water under pressure. Straight tubes, or U-tubes can be cleaned mechanically with rotary tube cleaners. After such cleaning the tubes should be blown with air.

The external surface of tubes in removable tube bundles may be cleaned by inserting a scraper bar between the tubes.

Exchanger Design Conditions

A most important consideration to which many purchasers of heat transfer equipment do not give full cognizance, is that the heat transfer rate is directly proportional to the pressure drops of the fluids. It is often desirable to have units quoted with an alternate bid for a different pressure drop. An economic study between exchanger costs and pumping costs can then be made. Some purchasers of feed water heaters and other exchangers ask for quotations by manufacturers in which each unit of pressure drop is evaluated at a stated cost. In comparing bids the pressure drop charge is added to the

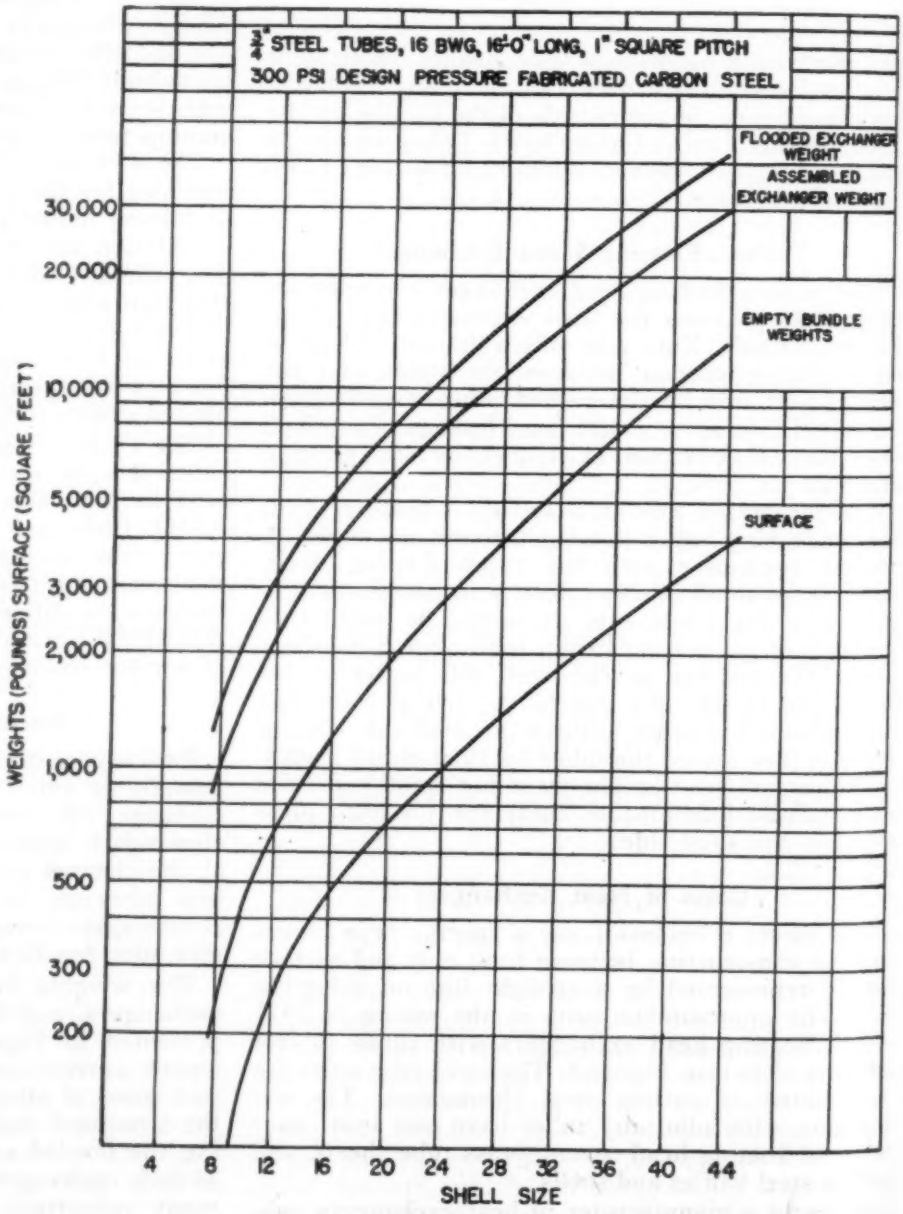


FIGURE 6
Weights and Surface of Floating Head Exchangers

exchanger cost and the purchaser accepts the most economical unit.

For a given pressure drop a higher heat transfer rate is always found on the shell side of an exchanger. Therefore, it is desirable to have the more viscous fluid on the shell side, if the allowable pressure drops are equal.

The tube side of an exchanger can be cleaned without removing the tube bundle from the shell. To minimize maintenance costs and shut downs it is desirable that the fluid, which has the greater tendency to foul, should be kept inside the tubes.

A corrosive fluid, which necessitates alloy construction should be kept inside the alloy tubes to eliminate the need for an alloy shell.

For high pressure service it is desirabe to keep the high pressure fluid on the tube side. To eliminate extremely heavy bolting at high pressures various manufacturers offer constructions in which the tube side channel cover is held in place by the tube side pressure. Channels and tube sheets are forged of a single piece of steel for such service.

In design it is most desirable that the process fluid temperatures do not cross within an exchanger, i.e., the cooler fluid should not be heated above the outlet temperature of the warmer fluid. Baffled exchangers do not provide true counter current flow. To compensate for this condition the logarithmic mean temperature difference must be corrected in order to design the unit. The correction factor for a single shell pass exchanger with two or more tube passes is generally 0.8, when the outgoing temperatures of the two fluids are identical. If there is any temperature cross, the correction factor decreases rapidly. Bowman, Mueller, and Nagle[3] question the use of factors below 0.8 in the design of exchangers.

If a temperature cross is unavoidable, it becomes necessary to provide two or more shell passes. A single exchanger shell can be provided with a longitudinal baffle, which will cause the shell side fluid to make two passes through the exchanger. Many purchasers of heat transfer equipment will not accept such construction, since leakage is apt to occur and difficulty is often experienced in removing and replacing the tube bundle for maintenance purposes. Generally two or more shells in series are used. The cost for a single shell with the same total surface would be considerably less.

Breidenbach and O'Connell[4] observed correlations of engineering accuracy between theoretical and actual heat transfer coefficients for the following types of equipment: partial condensers, total condensers, liquid to liquid exchangers, and gas exchangers. Their data show that heat transfer equations available in the literature, when used in conjunction with appropriate fouling factors can be used to predict overall heat transfer coefficients.

Figure 6 indicates the surface in exchangers with ¾-inch o.d. x 16-foot tubes spaced on one-inch square pitch. These surfaces approximate those found in exchangers constructed with tubes of varying size and pitch. Smaller tubes and close triangular pitch result in a greater surface in a given shell (length being held constant).

The number of tubes, which can be placed in an exchanger can be estimated from the following formula:

$$N = C\left(\frac{L}{P}\right)^2$$

N = number of tubes.
C = 0.75 for square pitch; 0.86 for triangular pitch.
P = tube pitch—inches.
L = outer tube limit—inches.

The outer tube limit is approximately equal to the shell i.d. minus 1½ inches for the floating head exchanger; to the shell i.d. minus ⅝ inch for fixed head, packed floating head, and U-tube construction.

NOTE

This paper was presented in September, 1947 at the Buffalo Regional meeting of the American Institute of Chemical Engineers.

ACKNOWLEDGMENTS

The author is indebted to American Brass Company, Downington Iron Works, The Lummus Company, and Pfaudler Co. for permission to reproduce drawings and to F. E. Hauck and R. R. Thompson for review of the manuscript.

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* * *

The Training of Process Operators

THE need for trained refinery personnel has been greatly accentuated since the war. During the war operation of refineries was largely maintained by means of a longer work week and the retention of workers past retirement age. Today we have a shorter work week, the loss of men eligible for retirement, and the inclusion in our work force of veterans whose military service interrupted their careers. Added to that is the increase in refinery operation. A training program is the only answer. Socony-Vacuum's successful plan is described herein.

As a result of the growing realization of the "human relations" and training programs in industry, the University of Texas conducted a nationwide survey on refinery training practices. These findings should be most valuable. This survey was sponsored by the Refining Division of the API which at its recent meeting in Philadelphia devoted an entire session to the topic. Also included was "Experiences in Establishing Organized Training Programs" by W. J. McClintock, general superintendent of the Baltimore refinery of Esso Standard Oil Company.

H. A. LUTZ and C. P. BAKER
Socony-Vacuum Oil Company, East St. Louis, Ill.

THE petroleum refining industry has for many years been a favored place for employment for the reasons that, generally speaking, there has been little seasonal fluctuation, the pay has been good, and the policies for employees have been progressive. Partly because of these factors, a high type of individual has sought employment in the oil industry and has remained with his job, progressing to better jobs as his experience and an expanding business activly permitted.

Confining this discussion to the process operator alone, and eliminating the skilled trades which are necessarily employed in large measure in the refining industry, the statement may be made that the skill required of a refinery employee is not one commonly available, and a large part of his training must be provided in the refinery. That this can be done efficiently has been demonstrated by the operation, in all parts of the world, of refineries containing highly complicated equipment in which native, and frequently uneducated, persons have successfully been taught the duties of process operators. Many of the war facilities installed in this country in the period from 1942 to 1945 were manned by a large percentage of people who had no previous experience in petroleum refining.

Operations Suffer from Inexperience

The refiner who used to depend on hiring common labor and advancing this unskilled person to the lowest operating job and, on passage of time, to higher operating jobs has in the past few years found that, through a combination of circumstances—such as installation of more complicated equipment, higher turnover of personnel due to a relatively high employment level in the country, loss of personnel to military services, and a more than normal rate of increase in capacity of refinery operations to meet an ever-increasing demand—positions in his operating setup are frequently filled with men not properly qualified for the job. The operations, therefore, suffer and the refiners's competitive position is impaired in proportion to the extent that he has been affected by the foregoing factors.

There exists, therefore, a definite challenge to management in the refineries to train the process operators to manipulate efficiently the complicated and expensive units which the technical people have designed and constructed. The installation of a modern cracking unit, alkylation unit, etc., does not mean that the refiner immediately achieves the benefit of greater or better production, for this comes only after the operators have been properly trained to handle economically the unit in a manner to justify the expenditure. There is no need to emphasize the loss which can occur due to an operating error when it is recognized that many of these units cost millions of dollars, and that, by a minor mistake such as turning a valve in the wrong direction, many lives may be endangered and the investment jeopardized.

Granting that a problem exists in the refining industry, varying only in degree between different refineries, the solution—or an approach to a solution—should result in improvement in the performance of work and an increasing improvement in the efficiency of operations.

Case History

This case history should help:

A recent survey of the growth and development of the Socony-Vacuum East St. Louis refinery since 1939 showed the need for a progressive training program. In 1939 the refinery equipment could process 7000 barrels per calendar day of crude, and the refinery personnel totaled 180. In January of 1940 a fixed-bed catalytic cracking unit had been completed and, with the necessary additional processing equipment, the refinery crude capacity had increased to 16,000

barrels per calendar day and the number of employes to 306. In 1943, because of wartime demands, additional equipment was built; and in the spring of 1944, when Thermofor catalytic cracking, alkylation units, and other new equipment went on stream, the refinery personnel had increased to approximately 700. Few of these additional employes had previous experience in a refinery and, therefore, required extensive training for efficient operation.

Prior to 1946 training of new employes was accomplished by having experienced personnel assist in breaking them in on the job. Before the start of the Houdry unit some of the process operators had acquired some breaking in on similar units in other company refineries, and also had obtained some knowledge from short manuals prepared from information furnished by other company units. Before the TCC and the alkylation units went on stream, process operators had journeyed to other refineries for operating knowledge and had read correspondence pertaining to experiences with these units. This training, although limited, was valuable.

Operating conditions for the units were established prior to 1946 in discussions by various members of plant management, although not always by all those directly concerned. Instructions usually were passed to the operators by word of mouth or by entry in the daily operating log books located at each unit. The shortcomings and inadequacies of such a method, epecially with inexperienced refinery personnel, were evident because instructions could be misunderstood; or, if they had been placed in the log book, they could not be readily found and consulted.

Written Instructions

In January 1946 the refinery manager recommended the use of written operating standards for stabilizing refinery operations. These standards were to contain established points of control, and copies were to be issued to the operating personnel. These standards were also to include a description of the method to be used for maintaining these points. It was evident that the proposed operating standards should help stabilize refinery operations. However, inasmuch as trained personnel is essential for efficient operations, a more extensive program was required. Approval for the additional training was readily obtained, and work was started on an operating manual that would describe in detail the refinery operations and equipment. The idea primarily was to take the mystery out of the jobs and to let the men know what they are doing and **why.**

The preparation of the operating standards and manual was assigned to the refinery technical division. The information was to be supplied by the various refinery divisions, viz., operating, maintenance, laboratory, engineering, and industrial relations. Before issuance, each section was to be approved by the operating division, the technical division, and the refinery manager.

In cooperation with the operating-division department managers, the technical personnel collected data and accomplished other necessary work essential to the writing of the operating standards. The department manager gave the first set of standards to the process operators of the crude unit for the purpose of finding out how the personnel would accept and react to them. Once in use, the minor shortcomings of these standards were noted; and the cooperation of those responsible for the operations resulted in improvements which are still being made for more efficient operations.

The operating conditions, as specified in the operating standards, were to be followed during normal operation. It was expected that abnormal conditions would arise and that temporarily the unit could not be operated within the limits as specified in the operating standards. As soon as these conditions could be corrected, it was expected that the control of variables would again be governed by the operating standards.

Manual Preparation Proves Beneficial

The operating manual as originally planned was to contain: 1) a brief history of petroleum and refining; 2) a brief history of Socony-Vacuum Oil Company, Inc.; and, 3) a description of each operating unit. Operating-unit descriptions were to include a general summary of the operation of each unit, the normal startup and shutdown procedure, and a detailed description of the mechanical equipment on the unit.

The completion of the operating standards and a general description for each unit were scheduled to appear in advance of the other parts of the manual because collection and publication of the balance of the information would require considerable time.

The general description of the crude unit was issued with the operating standards, in the spring of 1946, as the first section of the operating manual. This consisted of flow diagrams, with explanations of the various sources of feed to the unit as well as the disposition of the products. Some practical theory of fractionator operation was also included.

These first attempts to establish operating standards and an operating manual disclosed many new and worthwhile ideas. With this attempt to issue practical operating standards the technical personnel gained a much better practical knowledge of operations. Desirable points of control—which some refinery groups had previously not considered critical, but which others considered essential for efficient operations—were established. In brief, the operating experience and technical background of all refinery personnel were combined so as more nearly to approach the most economic, safe, and otherwise desirable methods of operation. This information was then issued as a printed manual, in one binder, to the personnel who supervise and operate the equipment.

Other Units

From the work on the crude unit, the program moved to the other refinery units. Because of past performances on the TCC unit, considerable time was spent in the preparation of standards and on an operating manual for this unit. In addition to the general description, the manual included some theory of catalyst flow—a new principle. For a thorough understanding of operations, therefore, it was felt that some idea of the engineering that had gone into the unit was desirable. Special equipment on the unit, as well as the complicated controls, were discussed in detail. Pump curves, showing the capacity at various heads and the power required of the prime mover, were also incorporated.

Management took the view that any information which the process operator needed or would find of interest should be supplied. It was felt that operators frequently react as they do because they are not furnished with sufficient information. Also, this was an

attempt to prove to the operator that management is more than willing to do its part in the achievement of desirable and efficient operation.

When the operating standards had been issued for a specific unit, a form was prepared. When filled out by that unit, it constitutes a summary of the previous 24 hours' operation. In addition to the control points, these sheets show an average of other operating conditions and provide for remarks on the unit's performance.

Daily Sheets Checked

These summary sheets are filled in each morning about 6 o'clock by the process operator and forwarded to the technical and engineering division, where they are checked for points off-standard. Duplicate copies are sent to the department manager, the operating superintendent, the technical and engineering-division manager, and the refinery manager. This sheet allows a quick evaluation of the unit's previous 24-hour operation, and also furnishes a continuous history of the operation for ready reference. The remarks on the summary sheet may initiate some immediate work to be done by refinery personnel not directly concerned with the unit's operation.

The standards having furnished the process operator with written required points of control, and the manual having furnished him with information helpful to the maintenance of desirable operation, the next step in the program was to give the operator a definite opportunity to express his opinions and ask any questions he might have in mind, as well as to present to him further information which could not be included in the manual.

Discussion meetings were periodically scheduled for the stillmen and operators, the two highest brackets in the operating division. These men are paid for their attendance at overtime rates. Firemen and utility men or any other refinery personnel are welcome to attend the meetings on their own time. Two meetings on the same subject are necessary to cover the personnel assigned to one unit, and from 10 to 20 individuals attend each meeting. These discussion groups are planned and conducted by the operating and technical divisions. The programs to date have included discussions on the operating standards and manuals; why control points were established; and other data which have resulted in the written work. Motion pictures and talks by specialists—such as electrical, mechanical, and instrument engineers—have also been programmed. During these discussions the process operator is urged to ask questions; and, if the answers are not readily available, every effort is made to obtain and supply them. A definite attempt is made to present information which can easily be accepted by the process operator rather than to give highly technical information not readily understood.

Benefits Reviewed

It should be appreciated that the foregoing program cannot be accomplished without cost. It should also be emphasized that the cost is a continuing one, for the reason new people are being brought into operations from time to time who require access to the same training currently going on. That there has been no question to date as to the benefit derived can be seen by reference to a few simple points regarding the improvements in the crude unit operation.

In 1946, after the establishment of the training program (including standards), crude throughput averaged in excess of 22,500 barrels per day. In 1945, 21,000 barrels per day had been considered top operation. The kerosine yield from the same crude unit averaged 3000 barrels per day in 1946, whereas previous operations had produced less than 2500 barrels per day—and this was considered efficient. The 90-percent point of the straight-run gasoline controlled by laboratory tests—with operators making adjustments depending on laboratory results, primarily on the basis of their own judgment—had varied more than 20° F. from day to day. Following the establishment of standards and proper training of the operator, the 90-percent point of the straight-run gasoline varied less than 6° F., and the control points were the temperature and pressure at the top of the tower rather than the result of laboratory tests. Other points in the unit's operation exhibited similar improvement over previous results.

Good Reception

Such a program has to be made attractive in order to gain the confidence and backing of the refinery personnel. Our observation is that the program to date is well received by the operating personnel not only in the hourly classification, but also the supervisory brackets. The program has increased the employe's interest by giving him a better understanding of the units and of his job. His questions are being answered, and it is obvious that the plan stimulates employe thinking which, in turn, tends to increase his feeling of responsibility, and to aid him in recognition of the fact that he and his job play an important part in the operations of the refinery. Incidentally, the availability of the information in manual form to the maintenance foremen has increased their appreciation of the importance of the work they are requested to do, and has improved measurably the cooperation necessary between operating and maintenance personnel to schedule maintenance work properly.

Indirect Advantages Also Seen

Another indirect advantage has accrued from the fact that operating personnel from outside plants are from time to time sent to the East St. Louis refinery for training in catalytic cracking. The data available in manual form have materially decreased the time required to train these guests adequately; and they have increased the confidence of the process operators to such an extent that a considerable portion of the technical staff's burden in training outsiders has been reduced.

The East St. Louis refinery is gratified with the results obtained in the initial steps of a program for the training of its process operators. It is recognized that the program is not yet complete, and there are other possible approaches. It is felt that the operating personnel in lower-bracket jobs could, and should, be more intensively trained than under present practice. As time permits, training at the lower levels is expected to be added to our program in order to give fundamental training to persons newly assigned to pump and valve operation, as well as training in techniques of firing, housekeeping, safety, and other items; so that these persons will have a better foundation for advancement and a greater appreciation for their responsibilities as they advance.

* * *

REFINER AUTHORS . . . . . and OTHER PERSONALITIES

F. L. NELSON | CHARLES P. BAKER | H. A. LUTZ | T. L. APJOHN

Socony-Vacuum Men Discuss Diesel Fuels

T. L. APJOHN, who with F. L. Nelson prepared the article "Diesel Fuels from Catalytic Cracking Operations," starting on page 90 of this issue, probably has enough experience in petroleum refining to "last the ordinary person a lifetime." After being graduated in 1934 with a B. S. in chemical engineering from Massachusetts Institute of Technology, he began work in refinery activity for Cities Service Oil Company. In 1936 he left to join Socony-Vacuum Oil Company in the technical service laboratories as a fuel technologist. He was called to the headquarters of the laboratories as fuel technologist, in New York City, in 1940.

From August, 1942, to August, 1945, he served with the PAW in Washington, D. C., as an aviation specialist and aviation officer. He returned to Socony-Vacuum, where he became assistant to the director of the laboratories in 1945. A year later he took over in the job he holds at present as supervisor of light products division, Research and Development Department of Socony-Vacuum Oil Laboratories, Paulsboro, N. J.

Apjohn enjoys golf, swimming, and spectator sports, but admits that with a family and a nine-room house constantly requiring something done, he finds little time for any of them. However, he likes traveling and seems to enjoy going to the various technical meetings which he attends from time to time.

He is a member of the Society of Automotive Engineers, American Chemical Society, and is active in the Cooperative Research Council and American Society of Testing Materials.

F. L. Nelson, the other author, was graduated with a degree in chemical engineering from the University of the State that is "round on the ends and high in the middle"—Ohio. He seems to have had the job he wanted in mind before graduation in 1941, because he left the Buckeye State the same year for New Jersey and Socony-Vacuum as an engineer to work on fuels utilization.

Since 1945, he has been engineer on the utilization of motor gasoline and diesel fuels at Socony-Vacuum's Research and Delevolpment Department at Paulsboro. He is a member of the SAE and active in the Cooperative Research Council.

Nelson is reported as highly interested in cameras and guns and has made a nice collection of these items.

Operator Training Described by Pair

"Training of Process Operators," by Charles P. Baker and H. A. Lutz, refinery manager and technical department manager, respectively, for Socony-Vacuum Oil Company, Inc., East St. Louis, Ill., begins on page 146 of this issue of REFINER. This excellent paper was presented by the authors at the mid-year meeting of the American Petroleum Institute's division of refining at Philadelphia, in May.

Baker, after graduating from A. & M. College of Texas in 1934 with a degree in chemical engineering, entered the Beaumont, Texas, refinery of Magnolia Petroleum Company. He advanced to the position of technical advisor to the operating department, and later was transferred to the technical department. During this time he also spent several months with Houdry Process Corporation in the development laboratories.

He entered the army as a reserve officer in December, 1942, and was given a PAW assignment. Later he became chief of the aviation section in PAW's refining division. After military service, he was transferred from Magnolia to the East St. Louis refinery of Socony-Vacuum as general superintendent, and was promoted to his present position as refinery manager in the fall of 1946.

H. A. Lutz is a graduate of the University of Tulsa, 1939, with a B.S. in petroleum engineering (refining). He joined Socony-Vacuum as a member of the process engineering group at the East St. Louis refinery. He was commissioned in the U. S. Navy in 1942 and attached as a petroleum officer to the Bureau of Ships. After short courses at various stations, he was attached to Standard Oil Company's Bayway refinery in charge of navy petroleum products. Later he was ordered to the Third Fleet in the South Pacific, serving as fuel officer. He returned to Socony-Vacuum when released from the Navy.

Developer-Author

CHARLES O. HOOVER

CHARLES O. HOOVER, refinery specialist for Air Reduction Sales Company, whose article describing the Airco-Hoover copper sweetening process for sweetening gasoline and other light dis-

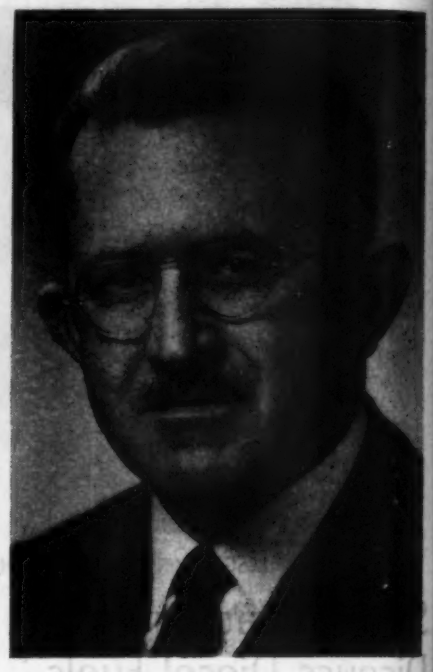
tillates begins on page 99, is the original developer of this process for continuous conversion of malodorous mercaptans by use of oxygen. Hoover patented the process in 1936 and has installed more than 40 units.

While he had been aware of the reaction between cupric chloride and mercaptans for several years, it was not until an endeavor to find a new market for the use of fuller's earth was made that he became impressed with the commercial possibilities of sweetening sour oils with cupric chloride-impregnated clay. During the experimental stages it was found that the impregnated clay quickly became inactive after contact with the sour oil but that by introducing oxygen into the sour stream the reduced cuprous salt was returned to a cupric state and the sweetening reaction was continuous. An experimental unit, forerunner of the present process, was installed and placed in satisfactory operation at the Shreveport refinery of Cities Service Oil Company.

Hoover studied mechanical engineering at Cooper Union in New York City and Northwestern University. While at Northwestern he became intrigued with chemistry and abandoned his mechanical engineering studies to pursue a career in chemistry. His efforts have been devoted to chemical research in the petroleum field and he maintains a research laboratory in Houston, where he is presently engaged in extensive research on several major refining problems.

Hoover is a member of the American Association for the Advancement of Science and a trustee and member of the board of directors of the Southern Association of Science and Industry.

P. L. PINOTTI



J. R. MacGREGOR

Diesel Fuel Study By California Trio

MacGREGOR, Pinotti, and MacPherson constitute the trio responsible for the paper, "Production and Performance of Diesel Fuels (starts on page 109), which was presented before the Society of Automotive Engineers, June, 1948. All are associated with California Research Corporation's laboratories at Richmond, Calif. J. R. MacGregor is associate director of the corporation; P. L. Pinotti is a research engineer, and G. R. MacPherson is senior research engineer in refinery technology.

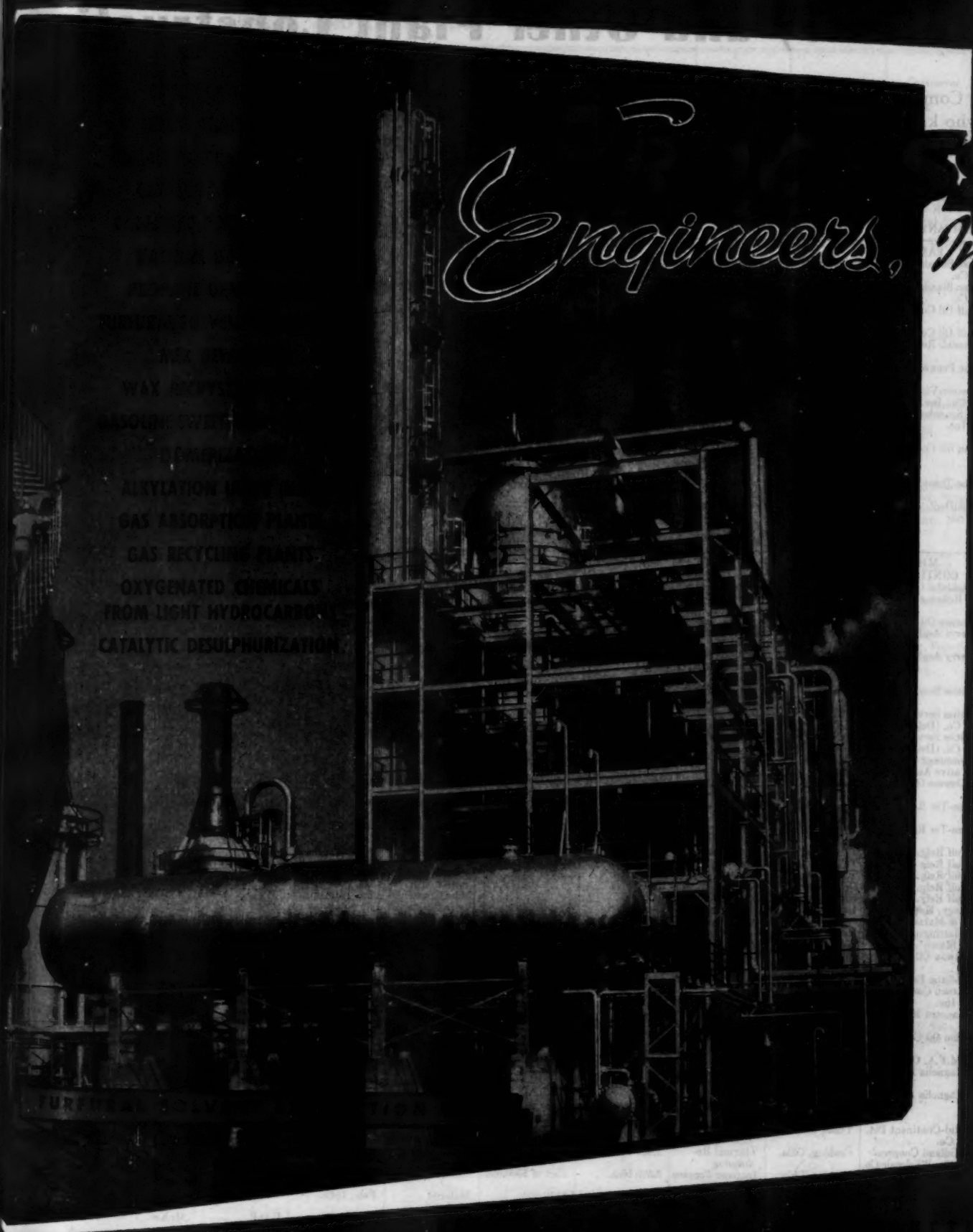
G. R. MacPHERSON

Except for a training and flying period in Texas at Brooks Field **MacGregor** has resided in California since his birth in Oakland. He is a 1923 graduate of the

■ CONTINUED ON PAGE 195

His Major Hobby Is Safety

Frank J. Sluze, safety director for Ashland Oil & Refining Company, Ashland, Ky., received his engineering training at Pennsylvania State College. After several years as production supervisor, he became a field director for the Department of Engineering Extension of his Alma Mater. About this time, the "safety bug" bit him, and he returned to industry, directing accident prevention in coal mining, steel manufacturing, ordnance plants; and during the past five years he has been with Ashland. His major hobby is safety, and he devotes considerable time to lecturing and writing on this subject. Secondary hobbies are music, reading and he is a passive athlete, willing to sit and watch any athletic event be it sand lot, high school, or college. (See his article, page 85.)


Engineers, Inc.
WAX
GASOLINE
ALKYLATION
GAS ABSORPTION PLANTS
GAS RECYCLING PLANTS
OXYGENATED CHEMICALS
FROM LIGHT HYDROCARBONS
CATALYTIC DESULPHURIZATION

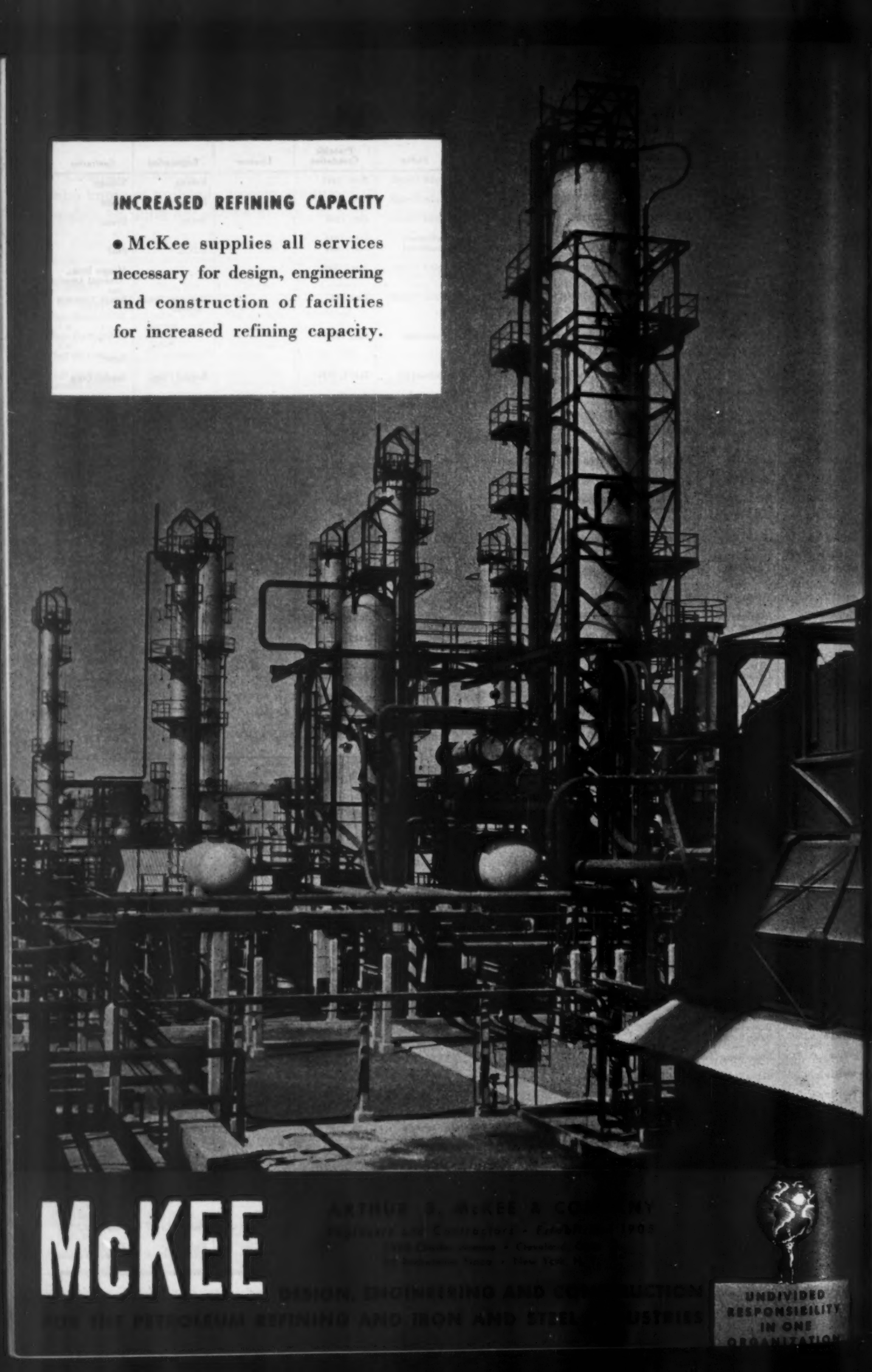
Refinery and Other Plant Construction

Companies whose projects are not listed or readers who know of unlisted projects are urged to: 1) send in data on units not shown herein; 2) furnish details which are missing in the current tabulation and 3) report from time to time on progress of such work. Such cooperation will be very much appreciated.

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
EAST									
Esso Standard Oil Co.	Linden, New Jersey	Vac. pipe still	49,000 bbls.	.....	Under Constr.	1st half, 1949	.....	S.O.D. & Braun	Braun
Esso Standard Oil Co.	Linden, New Jersey	Cat. Crack, Light Ends	41,000 bbls.	.....	Under Constr.	1st half, 1949	.....	S.O.D., Braun	Braun
Gulf Oil Corp.....	Philadelphia, Pa.	Naphtha, Polyform	16,000 bbls. (circ.)	.....	Under Constr.	.....	Gulf-Phillips	Lummus	Lummus
Gulf Oil Corp.....	Philadelphia, Pa.	Vacuum Unit	12,000 bbls.	.....	Under Constr.	.....	.....	Lummus	Lummus
Kendall Ref. Co....	Bradford, Pa.	De-ethanising Tower	50 bbls.	$15,000	Material on Order	Sept., 1948	.....	.....	.....
The Pennzoil Co....	Rouseville, Pa.	Boiler House add.	.....	.....	Contracted	Late 1948	.....	Dravo Corp.	Union Iron Wks. and Dravo
Socony-Vacuum Oil Co., Inc.	Paulsboro, N.J.	Crude, Lube Plant	.....	Part of $45 million	Under Constr.	Jan. 1, 1949	Texaco	Badger	Badger
L. Sonneborn Sons, Inc.	Petrolia, Pa.	Enlarge Acid Plant, Anti-Pollution	.....	$400,000	Approved	1948-49	.....	Chemical Constr. Co.	Morris Knowles & Co.
Sun Oil Co.....	Marcus Hook, Pa.	Lube, Wax, Anti-pollution Project	.....	.....	.....	.....	.....	.....	.....
The Texas Co.....	Eagle Pt., New Jersey	Vac. still, Cat. Cracking	40,000 bbls.	.....	Contract let	Late '49	.....	Kellogg, Texaco	Kellogg, Foster-Wheeler
U.S.Dept. of Interior	Bruceton, Pa.	Fischer-Tropsch Pilot Plant (Coal-to-gasoline synthesis)	5 bbls.	.....	Contracted	.....	.....	Blaw-Knox Co.	Blaw-Knox Co.
MID-CONTINENT									
*Ashland Oil and Refining Co.	Ashland, Ky.	Revamping TCC Kiln and Reactor	.....	.....	Under Constr.	.....	Houdry	Cat. Constr.	Cat. Constr.
Barsco Oil Co.....	Wichita Kans.	L. P. G.	250 bbls.	$100,000	Contract Let	Sept., 1948	Phillips	Born	Born
Berry Asphalt Co..	Stephens, Ark.	Expand Asphalt Plant	2,000 bbls.	.....	Under Constr.	Aug., 1948	.....	Staff	Staff
Berry Asphalt Co...	Waterloo, Ark.	Lub Unit, Expand Asphalt facilities	1,200 bbls.	.....	Under Constr.	Aug., '48	.....	Process Eng.	Process Eng.
Cities Service Oil	Chicago	Compounding & Grease Plant	1,500 bbls.	$2.5 million	Design	Early '49	.....	Sumner-Sollitt	.....
Cities Service Oil Co. (Delaware)	E. Chicago, Ill.	Modernize Plant	.....	$18 million	Under Constr.	Late '48	Kellogg	Kellogg	Kellogg
Cities Service Oil Co. (Delaware)	E. Chicago, Ill.	Laboratory	.....	$300,000	Under Constr.	July, '48	.....	Staff	Sumner-Sollitt
Consumer Co-operative Association	Coffeyville, Kansas	MEK Dewaxing	2,500 bbls.	$1.5 million	Contracted	1949	Texaco	Process Eng.	Process Eng.
*Dewese Oil Co.....	Weston, Ohio	Lube filtering unit, Desalting	250 bbls., 800 bbls.	$15,000	Under Constr.	Aug., 1948	Petroco	Staff	Staff
Fen-Ter Refg. Co...	Wynnewood, Okla.	Enlarge Asphalt Plant			Under Constr.	July, 1948	.....	Ref. Eng.	Ref. Eng.
Fen-Ter Ref. Co...	Wynnewood, Okla.	Asphalt Specialties Plant	8,000 bbls.	$250,000	Under Constr.	July, 1948	.....	Ref. Eng.	Ref. Eng.
Gulf Refg. Co.....	Toledo, O.	Top & Vac. Unit	32,000 bbls.	.....	Under Constr.	Oct., 1948	.....	Badger	Badger
Gulf Refg. Co.....	Toledo, O.	Fluid Cat. Crk.	15,500 bbls.	.....	Under Constr.	May, 1949	.....	.....	Kellogg
Gulf Refg. Co.....	Toledo, O.	Polyform Unit	5,000 bbls.	.....	Under Constr.	May, 1949	U.O.P.	.....	Kellogg
Gulf Refg. Co.....	Cincinnati	Fluid Unit	15,500 bbls.	.....	Under Constr.	June, 1949	.....	.....	Kellogg
Gulf Refg. Co.....	Cincinnati	Polyform Plant	5000 bbls.	.....	Under Constr.	June, 1949	U.O.P.	.....	Kellogg
Hagy, Harrington & Marsh	Hooker, Okla.	Gasoline and LPG Recovery	100,000 mcf	$2 million	Under Constr.	July 1, '48	.....	Pritchard	Pritchard
*Harrington & Marsh	Panoma, Okla.	Natural Gasoline & L.P.G. Plant	100,000 mcf.	$2 million	Under Constr.	Aug., 1948	.....	Pritchard	Pritchard
Hiwan Oil Co.....	Magnolia, Ark.	Gasoline Plant	10,000 mcf	.....	First Stage Completed	.....	.....	Petro. Eng.	Petro. Eng.
Indiana Farm Bureau Co-op. Assn., Inc.	Mt. Vernon, Ind	Enlarge Topping Unit	7,000 bbls.	.....	.....	Sept., 1948	.....	.....	Staff
Kanotex Refg. Co..	Arkansas City, Kans.	Cat Cracking	4,200 bbls.	$500,000	Contract let	Early '48	Phillips	Koch Eng.	Koch Eng.
Lion Oil Co.....	El Dorado, Ark.	Enlarge Ammonia Unit	570 tons	$3.5 million	Contracted	April, 1949	.....	Chem. Const.	Chem. Const.
*M.F.A. Oil Co....	Chanute, Kans.	Desulfurization	1,000 bbls.	$75,000	.....	Jan., 1949	Phillips	Koch	Staff
Magnolia Pet. Co...	Grant County, Kans., (Hickok)	Gasoline Plant	100,000 mcf	.....	Design	.....	.....	.....	.....
Magnolia Pet. Co...	Grady County, Okla., (Chitwood)	Gasoline Plant	30,000 mcf	.....	Design	.....	.....	.....	.....
Mid-Continent Pet. Co.	Tulsa, Okla.	Vac still, Cat Cracking	135,000 bbls.	$8.5 million	Contract let	Oct., 1948	Kellogg	Kellogg	Kellogg
Midland Cooperative Wholesale Co.	Cushing, Okla.	Thermal Reforming	1,400 bbls.	Part of $500,000	Under Constr.	Aug., 1948	U.O.P.	U.O.P., Ref. Eng.	Ref. Eng.
Midland Cooperative Wholesale Co.	Cushing, Okla.	Increase Topping Capacity	6,500 bbls.	Part of $500,000	Under Constr.	Aug., 1948	U.O.P.	U.O.P., Ref. Eng.	Ref. Eng.
*NewMexicoAsphalt Rfg. Co.	Artesia, N.M.	Crude Unit	7,500 bbls.	$350,000	Material Ordered	Feb., 1949	.....	Geo. Armistead	Staff
Ohio Oil Co.....	Robinson, Ill.	Vac Unit, Cat Crack, Crude Still, Poly, LP G Recovery	27,500 bbls.	$15 million	Under Constr.	Late '48	U.O.P.	McKee	McKee, Pritchard
Old Dutch Ref. Co..	Muskegon, Mich.	LPG Recovery	3,400 gallons	$45,000	.....	.....	U.O.P.	Staff	Staff
Old Dutch Ref. Co..	Muskegon, Mich.	Crack Plant Revamp	800 bbls.	$30,000	Under Constr.	July 1948	U.O.P.	Staff	Staff
*Osceola Refining Co., Inc.	Reed City, Mich.	T.E.L. Blending plant	1,000 bbls.	$25,000	Under Constr.	July, 1948	.....	Staff	Staff
Peteo Corporation	Blue Island, Ill.	Skim, & Crk.	10,000 bbls.	.....	Under Constr.	Summer, '48	.....	Clark's	Clark's
*Petroleum Specialties, Inc.	Flat Rock, Mich.	Increasing distillation, and other plant facilities	6,000 bbls.	$50,000	Under Constr.	Fall, 1948	.....	Staff	Staff
Phillips Pet. Co....	Kansas City, Kans.	Compounding Plant	.....	.....	Under Constr.	Oct., 1948	.....	Staff	Winn-Senter

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Phillips Pet. Co....	Kansas City, Kans.	Lubricating Unit	1,500 bbls.	.....	Under Constr.	Nov., 1948	.....	Kellogg	Kellogg
Phillips Pet. Co....	Kansas City, Kans.	Cat. Crack	24,000 bbls.	.....	Under Constr.	Oct., 1949	.....	Braun	Braun
Phillips Pet. Co....	Kansas City, Kans.	Cat. Poly	1,500 bbls.	.....	Under Constr.	Oct., 1949	.....	Braun	Braun
Phillips Pet. Co....	Guymon, Okla.	Absorption Plant	173,000 mcf	.....	Authorized	July, 1949	.....	.....	.....
Rock Island Refg. Corp.	Rock Island, Ind.	Fluid Cat, Crk.	10,000 bbls.	$1,200,000	Contracted	July, 1949	U.O.P.	U.O.P.	Staff
*Louis Rose Refining Co.	Saginaw, Mich.	Storage Terminal on Saginaw River	100,000 bbls.	.....	Under Constr.	Aug., 1948	.....	.....	Meager Bros., General American
Sinclair Refg. Co...	E. Chicago, Ill.	Crude, Cat. Cracker, Poly Plant & Lube Treating	55,000 bbls.	.....	Under Constr.	Late, '48	.....	Lummus, Braun, Sinclair	Braun, Lummus
Skelly Oil Co.....	Eldorado, Kans.	Crude Dist. Unit, Cat. Crk.	30,000 bbls.	.....	Announced	Jan., 1950	.....	.....	.....
Skelly Oil Co.....	Stephens Co., Okla.	Gasoline Plant	.....	.....	.....	.....	.....	.....	Born
Socony-Vacuum Oil Co., Inc.	E. St. Louis, Ill.	Thermal Cracker & Distillation	.....	Part of $45 million	Contract let	Jan. 1, 1949	.....	Bechtel Corp.	Bechtel Corp.
Socony-Vacuum Oil Co., Inc.	Augusta, Kans.	Cat Cracking	10,000 bbls.	Part of $45 million	Projected	.....	.....	.....	.....
Standard Oil Co., (Indiana)	Sugar Creek, Missouri	Cat Cracking	25,000 bbls.	.....	.....	Mid '48	.....	.....	Kellogg
Standard Oil Co., (Indiana)	Whiting, Ind.	Motor Oils Unit	.....	.....	Under Constr.	Mid 1948	.....	.....	Foster-Wheeler, Stone & Webster Kellogg
Standard Oil Co., (Ohio)	Lima, Ohio	Cat Cracking	16,000 bbls.	$11 million	Contract let	Late '49	U.O.P.	McKee	McKee
Standard Oil Co. (Ohio)	Lima, Ohio	Crude Distl., Coke	†15,000 bbls.	$5 million	Announced	.....	.....	.....	.....
Stanolind O & G Co.	Garden City, Kans.	Hydrocarbon Synthesis	100,000 mcf	.....	Under Constr.	Jan., 1950	.....	Hydro Research, J&L Constr.	Kellogg, Foster-Wheeler, Stone & Webster, J & L Constr.
Stanolind O & G Co.	Garden City, Kans.	Chemical Plant	130,000 lbs./yr.	.....	Contracted	Jan., 1950	.....	Badger	Badger
Stanolind O.& G. Co.	Ulysses, Kans.	Gasoline Plant	100,000 mcf	.....	Under Constr.	Fall, '48	.....	J & L Constr.	J & L Constr.
Sun Oil Co.....	Toledo, Ohio	Cat. Crack Crude Dist., Vac., Poly.	30,000 bbls.	$16 million	Announced	1950	Houdry	Houdry, Cat. Constr., Process Eng., Staff	Cat. Constr.
Sun Oil Co.....	Toledo, Ohio	Anti-Pollution Project	.....	$600,000	.....	.....	.....	Sun Oil	Cat. Constr.
The Texas Co.....	Lawrenceville, Illinois	Crude and Cat Cracking	20,000 bbls.	.....	Site being Cleared	1950	.....	Foster-Wheeler	Kellogg, Foster-Wheeler
The Texas Co.....	W. Tulsa, Okla.	Crude and Cat Cracking	30,000 bbls.	.....	Contract let	1949	.....	Staff, Kellogg, Foster-Wheeler	Kellogg, Foster-Wheeler
Trans-Marine O. Refg. Co.	S. Milwaukee, Wis.	Crude, Vac., Refrm, Desulf.	5,000 bbls.	$1.3 million	Under Constr.	.....	.....	.....	Ref. Eng.
U.S. Dept. of Interior	Louisiana, Mo.	Demonstration Oil-from-Coal Plant	80 bbls.	$4.4 million	Contracted	Oct., 1949	.....	Koppers	Koppers
Warren Pet. Corp.	Madill, Okla.	Gaso. Plant Enlargement	1,500 bbls.	.....	Projected	Jan. 1, 1949	.....	Hudson	Hudson
Warren Pet. Corp..	Maysville, Okla.	Gasoline Plant	8,000 bbls.	.....	Under Constr.	Jan. 1, 1949	.....	Dresser	Dresser
Wood River Oil & Refg. Co.	Hartford, Ill.	Cat Cracking gasoil, Cracking	8,500 bbls.	$1 million	Under Constr.	Late '48	Phillips	Koch Eng.	Koch Eng.
SOUTHWEST									
Alamo Ref. Co.....	Sweeny, Texas	LPG Fractionation	.....	.....	Authorized	Fall, 1948	.....	.....	.....
*Alamo Refining Co.	Sweeney, Texas	Cat Cracker Revision	.....	$150,000	Contract let	.....	.....	Phillips	Mason
American Republics Corp.	Silsbee, Texas	Gasoline and Cycling	56,000 mcf	$3 million	Under Constr.	Aug., 1948	.....	Gaso. Plant	Gaso. Plant
Arkla Oil Co.....	Rodessa, La.	Add Compressors	60,000 mcf	$325,000	.....	.....	.....	.....	Staff
Bryson Refg. Co....	Bryson, Texas	Run Down Tanks	2,000 bbls.	$3000	.....	.....	.....	.....	.....
Calumet Refg. Co..	Princeton, La.	Modernisation of Lube Plant	700 bbls.	.....	Under Constr.	Early '49	.....	Staff	Staff
Carthage Corp.....	Carthage, Field	Gasoline Plant	100,000 mcf	$3.5 million	Under Constr.	Jan. 1, '49	.....	Hudson	Hudson
Carthage Hydrocol, Inc.	Brownsville, Tex.	Hydrocol	64,900 mcf	$19 million	Under Constr.	1948	Hydro-Res. Inc., Texaco	McKee	McKee
The Chicago Corp..	Carthage, Tex.	Enlarge Gas. Plt.	210,000 mcf	$2 million	Authorized	June, 1949	.....	Staff	.....
Citcon Corp.....	L. Charles, La.	Lube Plant	6,000 bbls.	$30 million	Under Constr.	.....	Texaco, Max B. Miller	Max B. Miller Lummus, Citcon	Lummus, Max B. Miller
Cities Service Oil Co.	Pampa, Texas	Gasoline Plant	18,000 mcf	.....	Contracted	1949	.....	Walco	Walco
Continental Oil Co..	Sonora, Texas	Gasoline Plant	.....	.....	.....	.....	.....	.....	Brown & Root
*Duval Gasoline Co.	Benevidas, Texas	Adsorption Plant	10,500 mcf.	$100,000	Under Constr.	Late 1948	.....	Republic Oil Ref. Co.	Duval Gaso. Co
Esso Standard Oil Co.	Baton Rouge, La.	Light Ends Recovery	20,000 mcf	.....	Under Constr.	Last Qtr., 1948	.....	S.O.D., McKee	McKee
Esso Standard Oil Co.	Baton Rouge, La.	Polymer	4,000 bbls.	.....	Under Constr.	Last Qtr., 1948	.....	S.O.D., McKee	McKee
Esso Standard Oil Co.	Baton Rouge, La.	Pipe Still	58,000 bbls.	.....	Under Constr.	Last Qtr., 1948	.....	S.O.D., McKee	McKee
Esso Standard Oil Co.	Baton Rouge, La.	Dewaxing	4,000 bbls.	.....	Under Constr.	2nd Qtr., 1948	.....	Badger	Badger
Esso Standard Oil Co.	Baton Rouge, La.	Vacuum Pipe Still	18,500 bbls.	.....	Under Constr.	Last Qtr., 1948	.....	Braun	Braun
Esso Standard Oil Co.	Baton Rouge, La.	Vacuum Pipe Still	14,500 bbls.	.....	Under Constr.	Last Qtr., 1948	.....	S.O.D., McKee	McKee
Esso Standard Oil Co.	Baton Rouge, La.	Light Ends Recovery	11,000 bbls.	.....	Under Constr.	1st Qtr., 1949	.....	Braun	Braun
Ethyl Corp.....	Baton Rouge, La.	Mfg. Facilities	.....	$20 million	Announcement	.....	.....	.....	.....
Gilcrease Oil Co....	Arabi, La.	Skimming	6,000 bbls.	$250,000	Under Constr.	July 15, 1948	.....	Ampco	Ampco
Gray-Wolfe Co.....	Montgomery Co.	Gasoline Plant	13,000 mcf	$2 million	Under Constr.	Jan., 1949	.....	O. L. Olsen	O. L. Olsen
Gulf Oil Corp.....	Crane, Texas	Gasoline Plant	40,000 mcf	.....	Contracted	Fall, 1949	.....	Braun	Braun, W. D. Bowden
Gulf Oil Corp.....	Pt. Arthur, Tex.	3 Top & Vac. Units	22,000 bbls. ea.	.....	Under Constr.	Mid 1948	.....	.....	Badger
Gulf Oil Corp.....	Pt. Arthur, Tex.	Cat. desulf.	17,000 bbls.	.....	Under Constr.	.....	.....	Lummus	Lummus
Gulf Oil Corp.....	Pt. Arthur, Tex.	Naphtha Polyform.	32,000 bbls. circ.	.....	Under Constr.	.....	.....	Lummus	Lummus
Humble O. & R. Co.,	Overton, Texas (London Plant)	Add Propane, Absorption Refrigeration	Gas	.....	Under Constr.	Aug., 1948	.....	Fish Eng.	Fish Eng.
Humble O. & R. Co.,	Overton, Texas (American Plant)	Add Propane, Absorption	Capacity	$2 million	Under Constr.	Aug., 1948	.....	Fish Eng.	Fish Eng.
Humble O. & R. Co.,	Laird Hill, Texas (Kilgore Plant)	Add Propane, Absorption—Refrigeration	Unchanged		Under Constr.	Aug., 1948	.....	Fish Eng.	Fish Eng.


INCREASED REFINING CAPACITY
• McKee supplies all services necessary for design, engineering and construction of facilities for increased refining capacity.
McKEE
UNDIVIDED RESPONSIBILITY IN ONE ORGANIZATION

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Humble O. & R. Co.	Katy, Texas	Add Propane, Absorption	.....	$7 million	Under Constr.	March, 1949	.....	Stearns-Roger	Stearns-Roger
Humble O. & R. Co.	Kelsey Field, Texas	Gas Injection Plant	18,000 mcf	$1,408,000	Under Constr.	Jan., 1949	.....	Stearns-Roger	Stearns-Roger
Humble O. & R. Co.	Seeligson Field, Texas	Gas Injection Plant	20,000 mcf	$1,336,000	Under Constr.	Jan., 1949	.....	Stearns-Roger	Stearns-Roger
Humble O. & R. Co.	Conroe, Texas	Add Compression—Absorption	30,000 mcf	$4,160,000	Under Constr.	Summer, 1949	.....	Stearns-Roger	Stearns-Roger
Humble O. & R. Co.	Bloomington, Texas	Gas Comp. Plant	22,000 mcf	.....	Authorized	1949	.....	.....	.....
Humble O. & R. Co.	Opelousas, La.	Absorption Plant	100,000 mcf	$2,800,000	Authorized	Spring, 1949	.....	.....	.....
Humble O. & R. Co.	Pickton Field, Texas	Comp.—Absorp. Plant	18,000 mcf	$2,133,000	Authorized	Spring, 1949	.....	Fluor	Fluor
Humble O. & R. Co., Hutex O. & Refg. Co.	Baytown, Texas	Lube dewaxing	4,600 bbls.	$5 million	Under Constr.	Early '48	Texaco	Badger	Badger
	Hardin, Texas	New Crude Furnace	500 bbls.	$3,000	Under Constr.	Sept., 1948	.....	Staff	Staff
*Hutex Oil & Ref.	Hardin, Texas	Crude & Product Storage Facilities, Control House	20,000 bbls.	$75,000	Under Constr.	Sept., 1948	.....	Staff	.....
Magnolia Pet. Co...	Beaumont, Tex.	Lube Plant	.....	.....	Under Constr.	Jan. 1, 1949	Texaco	Lummus	Lummus, Kellogg
Magnolia Pet. Co...	Seeligson Field, Texas	Gasoline and Cycling	70,000 mcf Casinghead 150,000 mcf Cycled	.....	Under Constr.	April, '49 Partly Completed	.....	Hudson	Hudson
Magnolia Pet. Co...	Mamou, La.	Gasoline Plant	7,000 mcf	.....	Under Constr.	Late '48	.....	Staff, Gaso. Plant	Gaso. Plant
McCarthy Chem. Co.	Winnie, Texas	Petro-chem, Cat Cracking	5,000 bbls.	$3 million	Under Constr.	.....	Phillips	Fish Eng.	.....
Monsanto Chem. Co.	Texas City, Tex.	Rebuilding Petro-chem	.....	$6 million	Contract let	Aug., 1948	.....	.....	Bellows, Leonard
Peteo Corporation..	Marrero, La.	Skim & Crk	5,000 bbls.	.....	Under Constr.	Early '48	.....	Clark's	Clark's
*Phillips Pet. Co....	Andrews, Texas	Absorption Plant	24,000 mcf.	.....	Under Constr.	Oct., 1948	.....	.....	.....
Phillips Pet. Co....	Alvin, Texas	Absorption Plant	120,000 mcf	.....	Authorized	Sept., 1949	.....	.....	.....
Phillips Pet. Co....	Dumas, Texas	Absorption Plant	55,000 mcf	.....	Under Constr.	Sept., 1948	.....	.....	.....
Phillips Pet. Co....	Goldsmith, Tex.	Absorption Plant	†48,000 mcf	.....	Under Constr.	Nov., 1948	.....	.....	.....
Plomo Co.....	Auga Dulce Field	Processing Plant	30,000 mcf	$1 million	Under Constr.	"Soon"	.....	.....	.....
Pure Oil Co.....	Nederland, Texas	Lube Plant	.....	$9 million	Under Constr.	July, 1949	Texaco	Lummus	Lummus
Republic O. Refg. Co.	Texas City, Texas	Recondition Cat. Cracker	.....	$750,000	Under way	Aug., 1948	U.O.P.	Republic, U.O.P.	Mason
Republic O. Refg. Co.	Texas City, Texas	Poly Plant	.....	.....	Under Constr.	Aug., 1948	U.O.P.	Republic, U.O.P.	Mason
*Shamrock Oil & Gas Co.	Sunray, Texas	Increase Topping & Cracking Facilities	10,000 bbls.	$300,000	Material on Hand	Oct., 1948	U.O.P.	Staff	Staff
Sid Richardson Gasoline Co.	Keystone Field, Texas	Gasoline Plant	107,000 mcf.	.....	Under Constr.	Jan., 1949	.....	J & L Constr.	J & L Constr.
Shell Chemical Corp	Houston, Texas	Ethyl Chloride & Hydrochloric acid Unit	.....	.....	Under Constr.	June, 1948	.....	Kellogg	Kellogg
Shell Chemical Corp	Houston, Texas	Ethyl Alcohol Unit	.....	.....	Under Constr.	June, 1948	.....	Braun	Braun
Shell Chemical Corp	Houston, Texas	Ethyl Chloride Unit No. 2	.....	.....	Under Constr.	Sept., 1948	.....	Kellogg	Kellogg
Shell Chemical Corp	Houston, Texas	Sec. Butyl Alc. & M.E.K. Unit	.....	.....	Under Constr.	July, 1948	.....	Braun	Braun
Shel Chemical Corp	Houston, Texas	Glycerine Unit	.....	.....	.....	July, 1948	.....	Braun	Braun
Shell Chemical Corp	Houston, Texas	Hexylene Glycol Unit	.....	.....	.....	June, 1948	.....	Kellogg	Kellogg
Shell Chemical Corp	Houston, Texas	Ethylene Preparation Unit	.....	.....	.....	July, 1948	.....	Stone & Webster	Stone & Webster
Shell Oil Co.....	Notrees, Texas	Gasoline Plant	45,000 mcf	$5 million	Under Constr.	Early '48	.....	Brown & Root	Brown & Root
Shell Oil Co.....	Houston, Texas	Lube Unit	2,800 bbls.	$28 million	Under Constr.	July '48	Texaco	Lummus	Lummus, Kellogg, Fluor
Shell Oil Co.....	DenverCity, Tex.	Gasoline Plant	2,400 mcf	$1.6 million	Under Constr.	Fall, 1948	.....	.....	Fluor
Shell Oil Co.....	Norco, La.	Thermal Cracking, Asphalt Plt	12,000 bbls.	$1 million	Under Constr.	1948	.....	Shell	Shell
Sinclair Refg. Co.	Houston, Texas	Crude Still, Barrel House, Grease Works	30,000 bbls.	.....	Under Constr.	.....	.....	.....	Fluor
Southwestern Oil & Refg. Co.	Corpus Christi, Texas	Catalytic Reforming	5,000 bbls.	$800,000	Under Constr.	Aug. '48	.....	Process Eng.	Process Eng.
Stanolind O. & G. Co.	Fullerton Field, Texas	Gasoline Plant	.....	.....	Approved	.....	.....	J & L Constr.	J & L Constr.
Stanolind O & G Co.	Slaughter, Texas	Gasoline Plant	90,000 mcf	.....	Under Constr.	Feb., 1949	.....	Braun	Braun
Stanolind O & G Co.	Brownsville, Tex.	Chemical Plant	130,000 lbs./yr.	.....	Contracted	1949	.....	Badger	Badger
Stanolind O & G Co.	Pettus, Texas	Cycling Plant	166,000 mcf.	.....	Under Constr.	1949	.....	J & L Constr.	J & L Constr.
Sun Oil Co.....	Richland Parish, Louisiana	Gasoline Plant	70,000 gal.	.....	Under Constr.	May, '48	.....	.....	Pet. Eng., Inc.
Sun Oil Co.....	Starr Co., Tex.	Gasoline Plant	25,000 mcf	Part of $12 mil.	Bids asked	April, 1949	.....	.....	.....
Talco Asphalt & Refining Division American Liberty Oil Co.	Mt. Pleasant, Texas	Poly LPG Plant	2,800 mcf.	$285,000	Under Constr.	Aug., 1948	U.O.P.	Staff	Staff, Piping-State Const. Co.
The Parade Co.....	Rusk County, Texas	Add Propane Recovery	18,000 mcf	$250,000	Contracted	Dec., 1948	.....	Hudson	Hudson
The Texas Co.....	Port Arthur, Texas	Lube & Wax Additions	2,500 bbls. oil	.....	Under Constr.	Late '48	.....	Staff, Foster-Wheeler	Foster-Wheeler
The Texas Co.....	Lafitte, La.	Expand Gaso-Plant	6,500 mcf	.....	.....	.....	.....	Hudson	Hudson
*Texoma Natural Gas Co.	Stinnett, Texas	Additional Compression	150,000 mcf.	$2.5 million	Under Constr.	Jan., 1949	.....	.....	Midwestern Construction Co.
United Gas Co.....	Carthage, Tex..	2nd Gas Plant	100,000 mcf	$3.5 million	Under Constr.	July, 1949	.....	Hudson	Hudson
U.S. Ind. Chemicals Co.	Brownsville, Texas	Petrochemical Plant	.....	.....	Contracted	1949	.....	Badger	Badger
Waggoner Est. Ref..	Electra, Tex.	Crack Unit Revisions	.....	$250,000	Under Constr.	Fall, 1948	.....	Ref. Eng.	Ref. Eng.
Warren Pet. Corp..	Breckenridge, Texas	LPG Extraction	1,500 bbls.	.....	Under Constr.	Jan. 1, 1949	.....	Staff	Staff
Warren Pet. Corp..	Hawkins, Texas	Plant Enlargement	20,000 mcf	.....	Contract let	March, 1949	.....	Gaso. Plant	Gaso. Plant
Warren Pet. Corp..	Holliday, Tex.	Expansion & Propane prod.	2,500 bbls.	.....	Under Constr.	Jan. 1, 1949	.....	Staff	Staff
Warren Pet. Corp..	Taylor's Corner, Texas	Gasoline Plant	5,000 mcf	.....	Contract let	March , 1949	.....	Waico	Waico
Witco Hydrocarbon Corp.	Big Lake, Tex.	Gasoline Plant	2,500 bbls.	$2.6 million	Under Constr.	July '48	.....	Staff	Fish Eng.
Witco Hydrocarbon Corp.	Witco, Texas	Carbon Black	.....	Part of $3.5 million	Contracted	.....	.....	Fish Eng.	Fish Eng., Staff

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
ROCKY MOUNTAIN									
The California Oil Company	Rangely, Colo.	Gasoline Plant	25,000 mcf	$3 million	Under Constr.	Late 1948	.....	Hudson	Hudson
The Carter Oil Co..	Billings, Mont.	Crude Cat Crk	30,000 bbls.	$20 million	Under Constr.	3rd Qtr. 1949	.....	U.O.P., S.O.D.	Fluor
Continental Oil Co.	Billings, Mont.	Complete Ref., Cat. Crack	7,500 bbls.	$8.5 million	Under Constr.	1949	U.O.P.	U.O.P., J. & L. Constr.	J & L Constr
Continental Oil Co.	Denver, Colo.	Crude, Cat Crk.	7,500 bbls.	$4 million	Under Constr.	Fall 1948	Houdry, U.O.P.	Staff Lummus	Lummus
Gulf Oil Corp.....	Eunice, N.M.	Gasoline Plant	.....	.....	.....	.....	.....	Hudson	Hudson
*Phillips Pet. Co...	Oil Center, N.M.	Absorption Plant	†48,000 mcf	.....	Under Constr.	Nov., 1948	.....	.....	.....
Salt Lake Refg. Co.	Salt Lake City	Crude Dist. Unit	25,000 bbls.	$5 million	Under Constr.	Nov., 1948	.....	.....	Bechtel
Skelly Oil Co.....	Lea County N.M.	Expanding Gasoline Plant	60,000 gals.	.....	.....	.....	.....	.....	J. E. Carlson
Socony-Vacuum Oil Co., Inc.	Casper, Wyo.	Cat Cracking	4,000 bbls.	Part of $45 million	Under Constr.	Jan. 1, 1949	.....	Cat. Constr.	Cat. Constr.
*Southern Union Gas Co.	Bloomfield, N.M.	Gasoline Plant	20,000 mcf	$1 million	Contracted	June, 1949	.....	Refinery Maintenance	Refinery Maintenance
*Standard Oil Co. (Indiana)	Casper, Wyo.	Cat. Crack.	8,000 bbls.	.....	Under Constr.	Early 1949	.....	.....	Kellogg
Stanolind O & G Co.	Elk Basin, Wyo.	Gasoline Plant	12,000 mcf	.....	Under Constr.	April, 1949	.....	Stone & Webster	Stone & Webster
U. S. Bureau of Mines	Rifle, Colo.	Shale Oil Refy.	3,000 bbls.	$450,000	Under Constr.	Fall, 1948	.....	Ref. Eng.	Ref. Eng.
Utah O. Ref. Co....	Salt Lake City, Utah	Propane Desasphalting	10,500 bbls.	$2.5 million	Contracted	Early 1949	.....	Kellogg	Kellogg
Warren Pet. Corp..	Monument, N.M.	Gasoline Plant Enlargement	2,500 bbls.	.....	Under Constr.	Jan. 1, 1949	.....	Warren	Dresser Eng.
WEST COAST									
*Barnsdall Oil Co..	Newhall, Calif.	Gasoline Plant	40,000 mcf.	$1 million	Under Constr.	July, 1948	.....	Refinery Maintenance	Refinery Maintenance
California Asphalt Corp.	Portland, Ore	Airblown Stills, Tanks	.....	$150,000	Under Constr.	Dec., 1948	.....	.....	Staff
*Coline Gasoline Co.	Ventura, Calif.	Gasoline Plant	.....	.....	Contracted	.....	.....	Refinery Maintenance	Refinery Maintenance
General Pet. Corp..	Torrance, Calif.	Vacuum Flash Tower	32,000 bbls.	$565,000	Contracted	Nov., '48	.....	Braun	Braun
Hancock Chem. Co.	Watson, Calif.	Elemental Sulfur Plant	50 tons	$1 million	Engineering being completed	Nov., 1948	.....	Badger	Badger
Shell Chemical Co..	Martinez, Calif.	Pet. Additives Plant	.....	.....	Under Constr.	Late 1948	.....	Parsons	Parsons.
Robt. S. Lytle, Opr.	Coalinga, Calif.	H_2S Removal Plant	33,000 mcf	$175,000	Engineering in Course	1 year	Fluor	Fluor	Fluor
Shell Chemical Corp	Martinez, Calif..	Pet. Additives Plant	.....	.....	Under Constr.	Sept., 1948	.....	Parsons	Parsons
Shell Chemical Corp	Martinez, Calif..	Di-iso-butylene Unit	.....	.....	Under Constr.	Mid 1948	.....	Staff	Staff
Shell Chemical Corp	Pittsburg, Calif..	Add Ammonia Plant	225% of prewar	.....	Under Constr.	Nov., 1948	.....	Bechtel Corp.	Bechtel Corp.
Shell Chemical Corp	Pittsburg, Calif.	Add Ammonium Sulfate Plant	180% of prewar	.....	Under Constr.	Aug., 1948	.....	Bechtel Corp.	Bechtel Corp.
*Shell Oil Co.....	Ventura, Calif.	Gasoline Plant	.....	.....	Under Constr.	.....	.....	Staff	Refinery Maintenance
Standard Oil Co., of Calif.	Bakersfield, Calif.	Crude Dist, Cat Cracking	10,000 bbls.	$7.5 million	Announced	Mid '49	Braun	Braun	Braun
Standard Oil of Calif.	Bakersfield, Calif.	Thermal, Crk., Gaso. Stabil., Gaso. Treating	9,000 bbls.	.....	Contracted	.....	U.O.P.	U.O.P.	Braun
Standard Oil Co. of Calif.	El Segundo, Cal.	Filling Plant Modernisation	.....	$2 million	Under Constr.	Dec. '48	.....	.....	.....
Standard Oil Co. of Calif.	Richmond, (California)	Grease, Wax Plant, Dock Facilities	82,000 lbs.	$13 million	Under Constr.	Sept. '48	U.O.P.	W. G. Peugh	Barrett & Hilp, Swinerton & Walberg & Bea C.Gerwick, Inc. Humiston-Rosendahl, Inc.
*Standard Oil Co. of California	Richmond, Calif.	TCC Clay Repurification Unit	50 tons	$250,000	Under Constr.	Sept., 1948	Max B. Miller	Max B. Miller	Humiston-Rosendahl, Inc.
*Union Oil Co. of California	Oleum, Calif.	Revision of Refining Facilities	.....	$4.2. million	Engineering	1949	.....	R. H. Parsons Co.	.....
*Union Oil Co. of California	Oleum, Calif.	Revision of Lube Dewaxing Facilities	1,900 bbls.	$1.7 million	Contracted	1949	Union Oil Co.	Kellogg	Kellogg
*Union Oil Co. of California	Oleum, Calif.	Improvement to Compound & Grease Facilities	.....	$1.2 million	Engineering	1949	.....	J. M. Montgomery & Co.	.....
*Union Oil Co. of California	Oleum, Calif.	Duo-Sol Unit	6,000 bbls.	$2.9 million	Contracted	1949	Max Miller	Max Miller	Max Miller
*Union Oil Co. of California	Willmington, Calif.	Ethylene Production	100,000 lbs.	$2.5 million	Engineering	1949	Union Oil Co.	Foster-Wheeler	.....
*Union Oil Co. of California	Willmington, Calif.	H_2S Recovery	30,000 lbs.	$200,000	Engineering	1949	None	Ehrhart & Arthur, Inc.	
FOREIGN									
A. I. O. C.....	Abadan.....	Gas Plant.....	25,000 mcf	$2 million	Under Constr.	.....	.....	Badger	Badger
Agwi Pet. Corp....	Fawley, Eng.	.....	120,000 bbls.	$140 million	Projected	1952	.....	.....	.....
Anglo-Iranian Oil... Co.	Abadan, Persian Gulf	Cat. Cracker	30,000 bbls.	.....	Planned	.....	.....	.....	.....
Anglo-Iranian Oil... Co.	Adadan, Persian Gulf	Lube Plant	400 bbls.	.....	Planned	.....	Texaco	Badger	Staff
Bahrein Pet. Co.,. Ltd.	Bahrein Island	Expansion Program	.....	$8.9 million	Under Constr.	June, 1949	.....	U.O.P., Bechtel	International, Bechtel, Inc.
*Bataafsche Petroleum Maatschappij.	Rotterdam-Pernis	.....	60,000 bbls	.....	.....	.....	.....	.....	.....
*British-American Oil Co., Ltd.	Montreal East, P.Q.	Cat Craking and Cat. Poly.	13,300 bbls.	.....	Under Constr	Late 1949	Kellogg-U.O.P.	Kellogg	Kellogg
British Pet. Chem., Ltd.	Gangemouth, Scotland	Petro-chem	.....	$20 million	Planned	.....	.....	S & W, Badger	S & W, Badger
Burmah Oil Co.....	Burma.....	Furfural Plant	1,000 bbls.	$600,000	Planned	.....	Texaco	Badger	.....
Burmah Oil Co.....	Syriam, Burma..	Thermafor Clay Revivification	66 tons	$150,000	Design	1949	Max Miller, Socony-Vacuum	Max Miller	.....
Caltex Pet. Maatschappij, N.V.	Rotterdam, Holland	Crude Plant	20,000 bbls.	$18 million	Projected	Early '50	.....	McKee	McKee
Caltex Maatschap	Rotterdam	SO_2 Plant	1,800 bbls.	$600,000	Planned	.....	.....	Badger	.....
Consolidated Ref., Ltd.	Haifa, Palestine	Crude Plant	80,000 bbls.	.....	Planned	By 1950	.....	Badger	Badger
Consolidated Ref., Ltd.	Haifa	General Facilities	.....	.....	Under Design	.....	.....	Badger, Ltd.	.....

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licenser	Engineering	Contractor
Consolidated Ref. Ltd.	Haifa, Palestine	Lube Plant	2,500 bbls.	.....	Planned	.....	Texaco, Juik	Lummus Kellogg	Badger
Creole Pet. Corp.	Amuay Bay, Venezuela	Cat Cracking	60,000 bbls.	$70 million	Under Constr.	1950	.....	.....	.....
Creole Pet. Corp.	Molata Field, Venezuela	Stabilization and Repressuring Plants	.....	.....	.....	.....	.....	.....	.....
Creole Pet. Corp.	El Roble Field, Venezuela	Repressuring	.....	.....	.....	.....	.....	.....	.....
Egyptian Government	Egypt	Crude Plant	.....	.....	.....	.....	.....	Lummus	Lummus
Imperial Oil, Ltd.	Montreal, East, Canada	Crude Pipe, Still, Cat Cracker, Cat Poly	33,000 bbls.	$22 million	Under Constr.	Summer '48	.....	S.O.D., Kellogg	Kellogg
Imperial Oil, Ltd.	Edmonton, Canada	Thermal, Crack, Crude Dist.	6,000 bbls.	$7 million	Under Constr.	1948	.....	Barnes, Impl. Oil	Barnes
Imperial Oil, Ltd.	Leduc Field	Gas Absorption Plant	.....	$1.5 million	Projected	.....	.....	.....	.....
Industrie Chimiche Italiane Petroli	Mantau, Italy	Crude	4,500 bbls.	.....	.....	.....	.....	.....	.....
Kuwait Oil Co.	Kuwait	Topping Unit	20,000 bbls.	$2 million	Planned	.....	.....	Badger	Badger
McColl-Frontenac Oil Co., Ltd.	Montreal, East Que., Canada	Fluid Cat. & Cat. Poly.	40,000 bbls.	.....	Under Constr.	Mid 1948	.....	Kellogg	Kellogg
Mediterranean Ref. Co.	Sidon, Lebanon	SO_2 Extraction Plant	18,000 bbls.	.....	Contracted	Sept., 1949	.....	Badger	.....
Mediterranean Ref. Co.	Trans-Arabian P. L. Mediterranean Terminal	Refinery	.....	.....	"Paper stage"	.....	.....	.....	.....
Mene Grande	West Guara, Venezuela	Repressuring	.....	.....	.....	.....	.....	.....	.....
National Oil Refineries, Ltd.	Llandarcy Wales	Crude & Reform.	20,000 bbls.	$36 million	Contracted	.....	.....	Badger	Badger
National Oil Refineries, Ltd.	Llandarcy, Wales	Lubes & Wax	1,200 bbls.		Contracted	.....	.....	Badger	Badger
Petro Carbon, Ltd.	Partington, England	Cat Cracker, Lube & Reform	20,000 bbls.	.....	.....	.....	.....	.....	.....
Petro Chem., Ltd.	Partington, England	Petro Chemicals	.....	.....	.....	.....	.....	.....	.....
Petroleos Mexicanos	Ciudad Madero	Crude Unit	25,000 bbls.	$2 million	Under Constr.	July, 1948	None	Staff	Staff
*Petróleos Mexicanos	Poza Rica, Mex.	Gas Purification, Pressure Maintenance, etc.	.....	$13 million	Contracted	Early 1950	.....	McKee	McKee
Petroleos Mexicanos	Salamanca, Mex.	Crude, Gasoil, Cracking	30,000 bbls.	$12 million	Contract let	1949	U.O.P.	McKee	McKee
Porto Marghera Rfg.	Venice, Italy	Enlarging	.....	.....	.....	.....	.....	.....	.....
Raffineries de Pétrole de la Gironde	Ambes, France	Crude Plant	14,000 bbls.	$7.5 million	Under Constr.	Early 1950	.....	U.O.P., McKee	McKee
Scottish Oils, Ltd.	Grangemouth, Scotland	Crude	24,000 bbls.	$28 million	Planned	.....	.....	.....	.....
Scottish Oils, Ltd.	Grangemouth, Scotland	Cat Crk.	5,000 bbls.		Planned	.....	.....	.....	.....
Shell Chemical Corp.	Thornton, Eng.	Petro-chem	.....	Several millions	Under Constr.	.....	.....	.....	.....
Shell Chemical Corp.	Shell Haven, England	Petro-chem	.....	.....	.....	.....	.....	.....	.....
Shell Chemical Corp.	Stanlow, Eng.	Petro-chem	.....	.....	.....	.....	.....	.....	.....
Shell Oil Co. (Venezuela)	Cardón, Venezuela	Complete Refg.	.....	.....	Under Constr.	.....	.....	Lummus	Lummus
Shell Oil Co.	Heysham, Eng.	Remodel & Redesign Crude Plant	30,000 bbls.	.....	Under Constr.	Mid '48	.....	.....	.....
Société General des Huiles de Pétrole	Dunkirk, France	Crude Reform.	26,000 bbls.	.....	Under Constr.	.....	.....	.....	.....
Société General des Huiles de Pétrole	Courchelettes, France	Lube & Wax	800 bbls.	.....	Under Constr.	.....	.....	.....	.....
Standard Oil Co. of B.C., Ltd.	Vancouver, B.C.	Asphalt Plant	600 tons	$500,000	Under Constr.	Mid 1948	.....	Ralph M. Parsons	Staff
Stora Kopparberg	Sweden	Crude, Ther. Cracking	.....	.....	.....	.....	.....	Lummus	Lummus
Trent Oil Prod. Development Co.	North Shields, England	Crude Plant	11,500 bbls.	$4 to $8 million	Plans approved	.....	.....	.....	.....
Venezuelan Pet. Co., (Sinclair)	Puerto la Cruz, Venezuela	Refinery	35,000 bbls.	.....	Clearing site	.....	.....	.....	.....
*Yacimientos Petroliferos, Fiscales	La Plata Argentina	Crude Topping, Gaso Treating	50,000 bbls.	$2.8 million	Under Constr.	Early 1949	.....	Houdry Process Cat. Constr.	Cat. Constr.
Yacimientos Petroliferos Fiscales Bolivianos	Sucre, Bolivia	Crude Plant	3,000 bbls.	.....	.....	.....	.....	Foster-Wheeler	Foster-Wheeler
Yacimientos Petroliferos Fiscales Bolivianos	Cochabamba, Bolivia	Topping & Reforming Units	5,000 bbls.	.....	.....	1949	.....	Foster-Wheeler	Foster-Wheeler
YPF Brasil	Santos, Brazil	Complete Refg.	20,000 bbls.	$30 million	Projected	.....	.....	.....	.....

* First appearance in tabulation. † Added capacity.

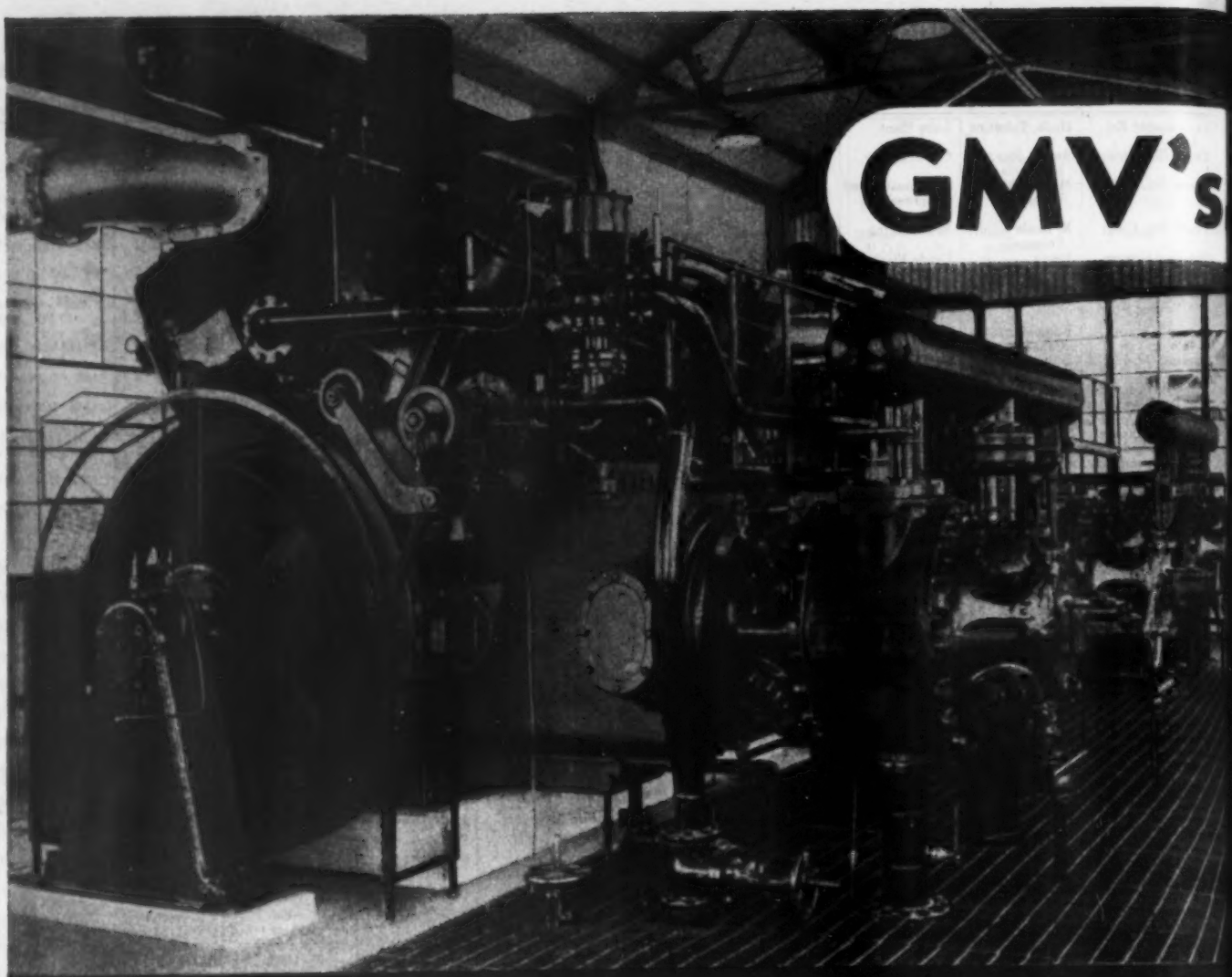
NOTE—Ampco—Ampco Engineering Co. Badger—E. B. Badger and Sons. Barnes—W. M. Barnes & Co. Bechtel—Bechtel Bros., McCone Co. Bellows—W. S. Bellows Co. Braun—C. F. Braun Co. Cat. Constr.—Catalytic Construction Co. Chem. Constr.—Chemical Construction Co. Clark's—Clark's Conarruction and Engineering Co. Dresser—Dresser Engineering Corp. Fish Eng.—Fish Engineering Corp. Fluor—Fluor Corp. Gaso. Plant—Gasoline Plant Construction Co. General American—General American Transportation Co. Houdry—Houdry Corp. Hudson—Hudson Engineering Corp. Hydro Res.—Hydrocarbon Research, Inc. J & L Constr.—Construction Division, Jones & Laughlin Supply Co. Kellogg—M. W. Kellogg Co. Koch Eng.—Koch Engineering Co. Koppers—Koppers Co., Inc. Leonard—Leonard Construction Co. Lummus—The Lummus Co. Mason—Mason Brothers Construction Co. McKee—Arthur G. McKee Co. Mid-Continent—Mid-Continent Engineering Co. Max Miller—Max B. Miller & Co. Parsons—Ralph M. Parsons Co. Pet. Eng.—Petroleum Engineer, Inc. Pritchard—J. F. Pritchard Co. Process Eng.—Process Engineers, Inc. Ref. Eng.—Refinery Engineering Co. Standard Oil Development Co. Stearns-Roger Manufacturing Co. Texaco—Texaco Development Co. U.O.P.—Universal Oil Products Co. Walco—Walco Engineering. Wohfeld—Wohfeld Construction Co. ⁴ Equally owned by California Texas Corp. and Socony-Vacuum Oil Co., Inc.

"Stanosyn" Plant Started

Construction work on Stanolind Oil and Gas Company's hydrocarbon synthesis plant at Garden City, Kans., was due to start July 1. Crews working for Stone and Webster Engineering Corporation, one of the four contractors on the project, were to begin preparing the site five miles east of Garden City.

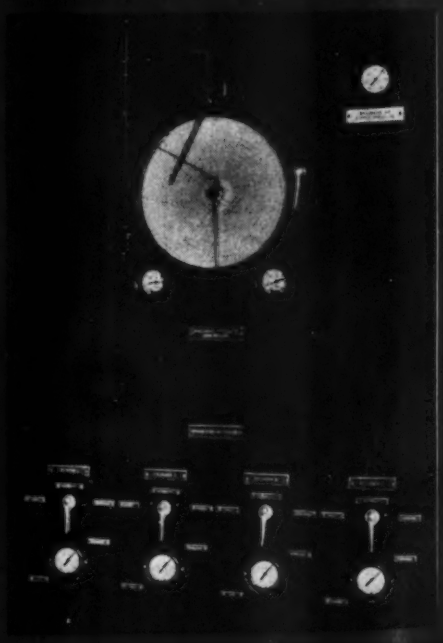
Schedule for construction work on the three major plant units will be announced soon. These units include the oxygen plant, the synthesis unit, and the chemical refining plant.

The official name for the company's synthetic gasoline and chemical plant at Garden City will be the "Stanosyn Plant."



Complete flexibility of control is a feature here at Southern Natural Gas Company's Wetumpka compressor station. These two GMV, 600 hp V-angles are set up for full automatic control or partial or full manual control of either or both units.

Control panel includes master pressure controller, applicable to either suction or discharge pressure, with provision for overall simultaneous manual control of speed and unloading. Four manual air switches provide for manual, individual unloading of crank end of each cylinder.



TYPE GMV ANGLE Compressors

New York Washington Bradford, Pa. Parkersburg, W. Va. San Francisco, Cal. Seattle, Wa

...s. the perfect answer to a problem at Wetumpka

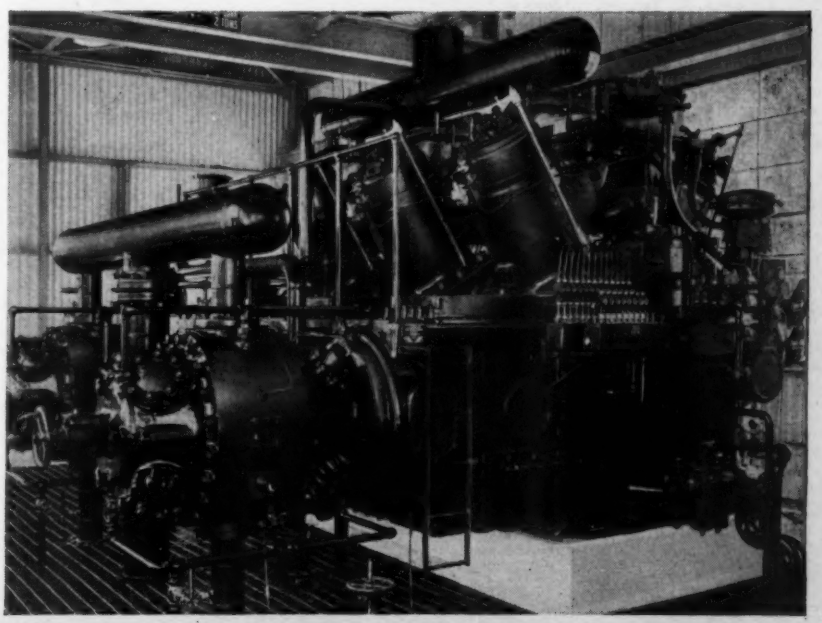
At Southern Natural Gas Company's Wetumpka, Alabama compressor station the gas supply drops during part of the day. It is desirable to maintain a constant discharge pressure when the supply is up; but not less than a specific suction pressure when the supply is low. Here again, GMV's are teamed with a patented Cooper-Bessemer method of automatic control for the ideal answer.

Automatic speed control is interposed between each step of 4-step, automatic-pneumatic compressor unloading.

THE ADVANTAGES ARE MANY

1. Positive, even control of either suction or discharge pressure at will, and without excessive speed range. Engine operation is remarkably stable.
2. At any capacity from 33⅓% to 100%, compressor capacity exactly matches load demand without continual loading and unloading of compressor steps.
3. All loading steps occur at maximum engine speed, where load increases are easily absorbed.
4. All unloading steps occur at minimum speed, where slight speed increase due to reduced load is not objectionable.
5. Compressor steps are not continually in operation, off and on, but remain in one position until load demand changes sufficiently to require additional steps.
6. Controlled pressure is exceptionally smooth and regular, free from the constant up-down variation common with previous step unloading systems.

Whether or not you need automatic control at its best, you'll always be ahead with Cooper-Bessemers. For Cooper-Bessemer V-angles — the modern GMV's and GMX's, 200 to 1000 hp — are first of all exceptionally reliable and efficient units for any kind of compressor service.



Each GMV drives two compressor cylinders, with provision for one step of unloading at one end of each cylinder, either automatically or manually controlled from control panel.

...rs by Cooper-Bessemer

MOUNT VERNON, OHIO AND GROVE CITY, PENNA.

...ttle, Wa... ...uston, Dallas, Greggton, Pampa and Odessa, Texas Tulsa Shreveport St. Louis Los Angeles

Refinery Runs Continue Upward Trend in Mexico

L. J. LOGAN
Economics Editor

REFINERY runs of crude oil in Mexico were again increased in 1947, extending the rising trend that has been under way for several years. Runs to stills for the year averaged 135,478 barrels daily, indicating total runs for the year were approximately 49,450,000 barrels. The runs of 135,478 barrels daily represented 88.0 percent of the available crude distillation capacity of 154,000 barrels daily.

The year's total runs of almost 50 million barrels in 1947 compared with about 42½ million barrels charged to stills in 1946. The increase reflected especially the commencement of operation in March 1947 of new facilities at Atzcapatzalco in the suburbs of Mexico City.

Partly offsetting the initiation of that new capacity was the temporary withdrawal of some capacity from operation in the Tampico area. The Mata Redonca refinery there has been out of service since August 1947 for general repairs. It is expected to be back in operation by the end of 1948.

Mexico's refineries in 1947 absorbed a large proportion of the country's crude oil production, which amounted to approximately 56 million barrels for the year or an average of about 153,600 barrels daily. Some of the crude oil was used as such for fuel and the remainder was largely exported. There was also apparently some exportation of crude oil and products from storage. On balance, Mexico in 1947 was a net exporter of approximately 9,714,710 barrels of all oils, including net export of 6,901,830 barrels of crude and 2,812,880 barrels net export of refined products.

These figures are indicated from the records of exports and imports. Total exports amounted to about 14,507,535 barrels and included 7,002,295 barrels of heavy and light crude and 7,505,240 barrels of refined products. Imports totaled about 4,792,825 barrels and included 100,465 barrels of crude oil and 4,692,360 barrels of refined products. Mexico's exports of crude oil, fuel oil, and asphalt exceeded imports of those products. But gasoline was imported in larger volume than it was exported, and kerosine was imported but not exported. There were also certain special products which were imported but not exported, such as paraffin and lubricating oils.

The refinery project at Mexico City and the related Poza Rica field installations cost $147 million Mexican currency, including $48½ million cost of materials purchased in the United States and $98½ million for labor, materials, and expenses in Mexico. Part of the capital was borrowed from the U. S. Export-Import Bank.

The next refinery construction project scheduled by Petroleos Mexicanos, the government oil monopoly, includes a refinery of 30,000 barrels per day crude oil capacity at Salamanca, state of Guanajuato, and the pipe line to supply it, forking off from the Poza Rica to Mexico City system. Purchasing of materials for that refinery is under way. The pipe line is being built mainly with pipe manufactured in Mexico. This complete project will require estimated investment of approximately $95½ million Mexican currency, including $40 million for imported materials and $55½ million for labor, materials, and expenses in Mexico.

Initial stage of work at Poza Rica field

Industry Survey of Refineries Located in Mexico as of May 1, 1948

Operating Company	Parent Company	Location	Type of Plant	Potential Crude Distillation b/d Capacity	Actual Crude Runs to Still b/d (1947)	Principal Types of Field Stock Normally Run	Major Products	CRACKING FACILITIES: Type	Charge b/d Capacity	Production Cracked Gasoline b/d	General Comments
Pemex "Arbol Grande"	Pemex	Arbol Grande, Tampico, Tamps.	Atmospheric Distillation down to Asphalt.	18,400	16,606	Poza Rica 81.30 Panuco 18.70	Percent Gasolines 12.45 Kerosine 10.43 Gasoil & Diesel 14.15 Fule Oil & Residue 58.38 Luboils 0.61 Asphalt 1.38 Paraffin 0.09 Various 0.45				
"Ciudad Madero"		Cd. Madero, Tampico, Tamps.	Skimming, followed by asphalt stills	49,000	47,255	Poza Rica 58.53 Naranjos 31.49 Panuco 9.98	Gasoline 14.80 Kerosine 3.14 G. O. & D. 9.54 F. O. & Res. 66.32 Asphalt 3.27 Paraffin 0.53 Various 1.30	Dubbs Thermal Dubbs Thermal Clark Thermal	3,600 Gasoil or Pressed Oil 1,000 Gasoil 1,800 Cracked Gasoil Dubbs	864 450 121	Originally "Reformer"—later converted to cracking unit. Ex "Bella Vista"—now operating as unit of "Ciudad Madero."
"Mata Redonda"		Villa Cuauhtemoc, Veracrus	Skimming	9,600	9,015	Poza Rica 54.63 Naranjos 42.27 Panuco 3.10	Gasoline 17.92 Kerosine 6.43 G. O. & D. 1.74 F. O. & Res. 68.56 Luboils 0.08 Various 2.60	Kellog Thermal	5,800 Poza Rica Light Residue	969	Out of service since August, 1947 for general repairs—expected to be in operation by end of 1948.
"Poza Rica"		Poza Rica, Veracurs	Skimming	6,000	3,127	Poza Rica 100.00	Gasoline 20.46 Kerosine 7.45 G. O. & D. 6.33 F. O. & Res. 64.39				
"Minatitlan"		Minatitlan, Veracrus	Skimming followed by Vacuum distillation	26,000	19,912	Isthmus 90.50 Naranjos 8.36 Panuco 1.14	Gasoline 13.81 Kerosine 8.91 G. O. & D. 11.20 F. O. & Res. 60.62 Luboils 2.70 Various 0.02				
"Atacapatsaloo"		Mexico City, Dist. Fed.	Skimming	45,000	39,563	Poza Rica 99.98 Panuco 0.02	Gasoline 32.19 Kerosine 10.14 G. O. & D. 2.85 F. O. & Res. 51.59 Various 1.20	Dubbs Thermal	11,700 Light Residue	2,562	Began operation March, 1947.
Totals				154,000	135,478	Poza Rica 65.52 Naranjos 15.03 Panuco 6.15 Isthmus 13.30					

New Plants Installed at the Poza Rica Field—Crude stabilization, capacity 90,000 b/d.
Absorption, plant, capacity 80,000,000 cu. ft. per day.
Gas purification, capacity 2,000,000 cu. ft. per day.

complete profile of fuel characteristics

the possible knock-limited combinations of compression ratio, manifold pressure and engine speed for a given fuel.

A tool for the development of future fuels

The special single-cylinder research engine in the Ethyl Laboratories is particularly well adapted to programs involving fuel development. Under carefully controlled conditions, antiknock determinations can be made over a broader range of conditions than is ever likely to be encountered in service. Extreme flexibility of adjustment of the engine and all associated equipment makes it possible to duplicate the complete range of service conditions and of fuel ratings without resort to abnormal adjustments. This versatile knock-testing equipment is used in Ethyl's program of service to the oil industry through:

1. Implementing complete explorations of the antiknock characteristics of experimental fuels.

2. Providing a fixed base line against which comparisons can be made in the development of engines and gasolines.

This is the fourth advertisement in a series. Future advertisements will discuss other phases of the problem faced by refiners in providing gasoline for today's and tomorrow's engines, and the contribution of the Ethyl Corporation to their solution.

ETHYL CORPORATION
RESEARCH LABORATORIES
1600 West Eight Mile Road, Detroit, Michigan
2600 Cajon Road, San Bernardino, California

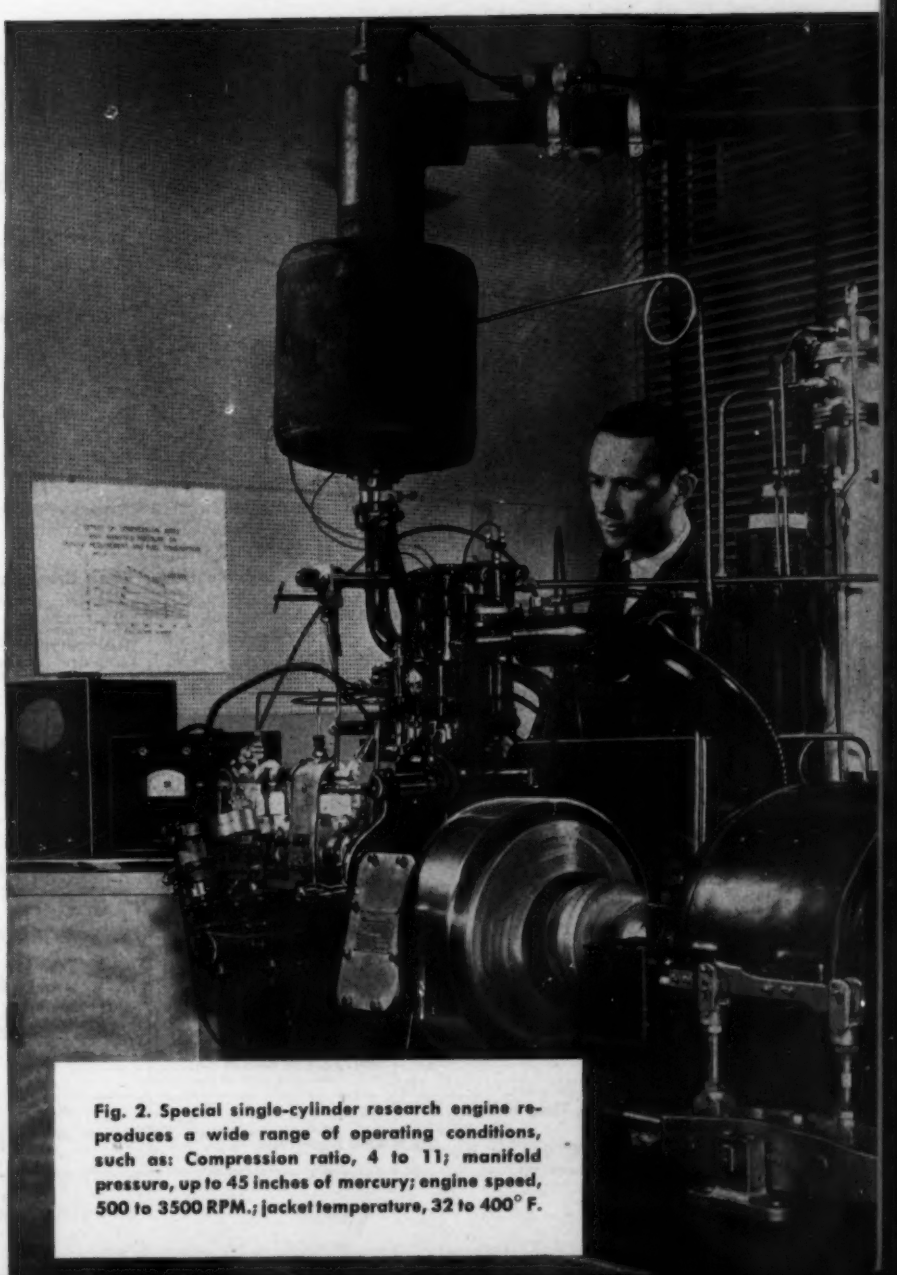
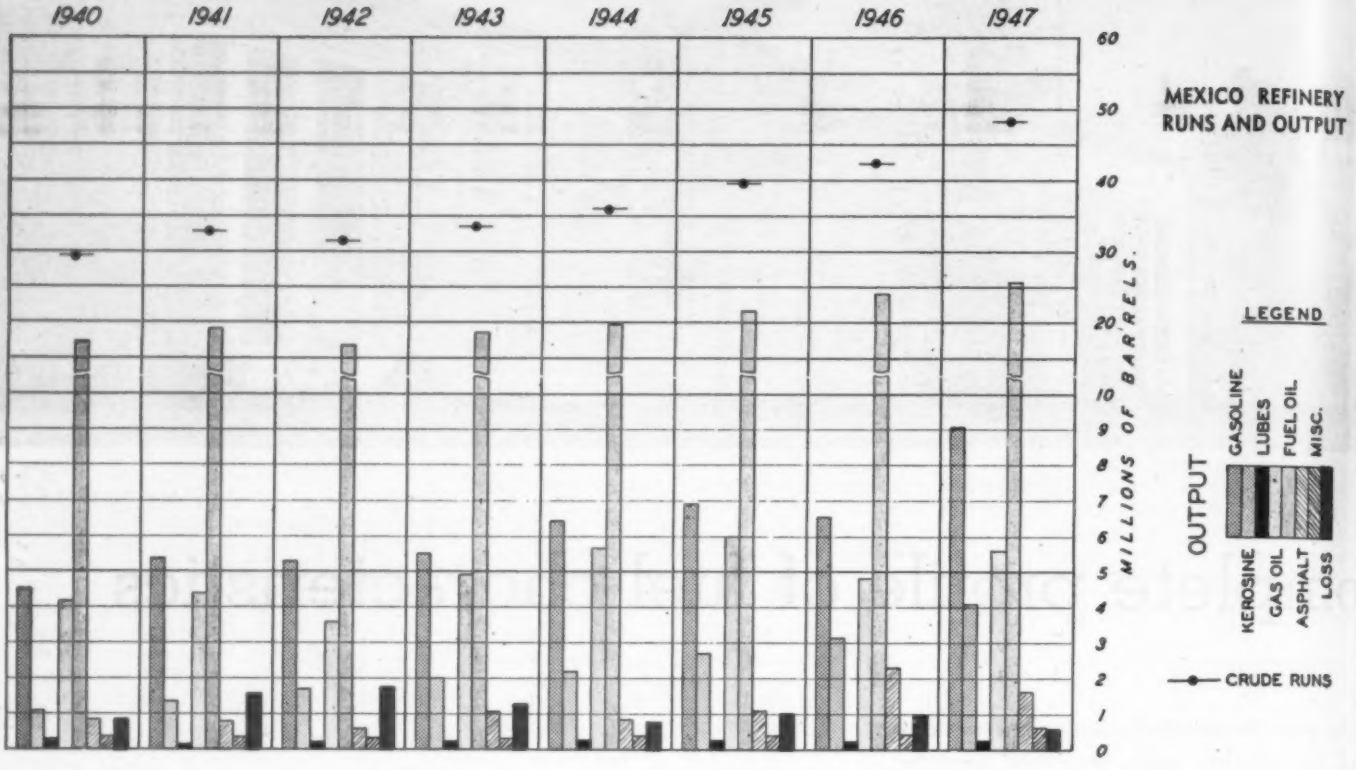


Fig. 2. Special single-cylinder research engine reproduces a wide range of operating conditions, such as: Compression ratio, 4 to 11; manifold pressure, up to 45 inches of mercury; engine speed, 500 to 3500 RPM.; jacket temperature, 32 to 400° F.



in connection with the Mexico City refinery expansion project has included construction of an absorption natural gasoline plant, a crude oil stabilization plant, and a pipe line system in the field for gathering gas from the wells and delivering it to the plants. Plans call for construction of a new natural gas pipe line from Poza Rica to Mexico City, for delivering 50 million cubic feet of gas daily for industrial use at the national capital.

The completed and projected installations will permit a total extraction of natural gasoline from Poza Rica natural gas, removal of sulphur from gas to be used for fuel, utilization of eliminated sulphur, and finally, the return to the reservoir of the volume of dry gas estimated as necessary to maintain the reservoir pressure at efficient levels, in order to obtain the best field production conditions and the maximum ultimate recovery. It has been estimated that these Poza Rica projects will require an investment of $61½ million Mexican currency, of which $21 million covers imported materials and $40½ million labor, materials, and expenses in Mexico.

The Petroleos Mexicanos development program contemplated for the early future puts considerable emphasis on refining facilities. Tentative projects include the following:

1) Lubricants and paraffin plant at the Mexico City refinery; total investment $47,650,000 Mexican currency.

2) Pipe line across the Isthmus of Tehuantepec and a refinery on the Pacific Coast, estimated total investment $33,150,000 Mexican currency.

3) Cracking plant at Tampico, total investment $25 million Mexican currency.

4) Refineries at Guadalajara, investment $24,080,000.

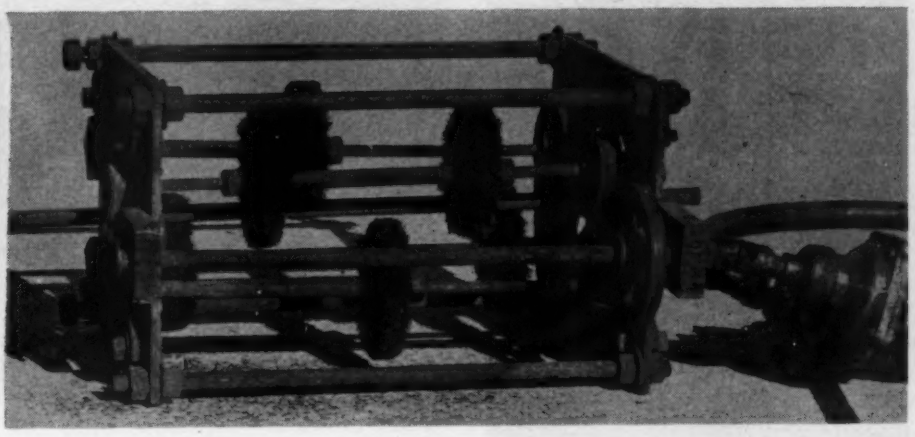
5) Refineries at Monterrey and Torreon, total investment $100 million Mexican currency.

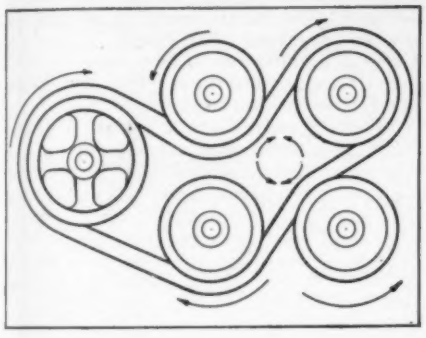
To cover the cost of the new Mexico City refinery and supplementary installations a loan was negotiated with the U. S. Export-Import Bank for $48½ million Mexican currency, to be redeemed in 5 years as from 1946. To date, all installments of principal and interest of this debt have been met when due and even paid in advance, stated Antonio J. Bermudez, general manager of Petroleos Mexicanos.

Industry Survey of Major Process Facilities in Mexico Other Than Crude and Cracking Units. (All Property of Pemex)

REFINERY	Location	Type of Plant	1948 Aviation Gasoline Production b/d	Capacity b/d	Type of Charging Stock	Yield to Light Alkylate	Yield to Isobutane
"Atascapatzalco"	Mexico City, Dist. Fed.	Isomerization	1,200	660	Butane (Normal)		44.41%
		Alkylation		1,500	Isobutane 38.61% Butane Butilene 61.39%	48.22%	
Approximate Composition of Aviation Gasoline			91-98 Oct.	100-130 Oct.			
		Isopentane	20.0%	24.5%			
		Light Naphtha	44.2%	7.5%			
		Light Alkylate	35.8%	68.0%			
		Fractionation		4,200	Butanes and Pentanes		
"Minatitlan"	Minatitlan, Veracruz	(?)	100	.....	Straight run gasoline from Isthmus (mainly Filisola) crude, TEL used to increase octane.		
		High Vacuum Tower	.....	5,500	Residues from Isthmus & Panuco Crudes—approximate yield 18.0% basic lubes; 31.0% gasoil and 50% heavy residue.		
		Lube Rerun Plant	.....	800	Light and heavy lubes.		
		Edeleanu Plant	.....	2,000 or 600	Kerosine. (Depending on alternative uses of plant.) Lubes.		
"Ciudad Madero"	Cd. Madero, Tampico, Tamps.	Wax Plant	.....	5,000	POD—approximate yield 94.0% pressed oil and 5.0% paraffin (40 tons daily).		
		Absorption for Sabilisation	.....	.....	Charging capacity 3,937,500 cu. ft. daily wet gas from cracking plants.		
"Arbol Grande"	Arbol Grande, Tampico, Tamps.	Wax Plant	.....	400	POD—approximate yield 94.5% pressed oil and 4.5% paraffin (3 tons daily).		
		Lube Rerun Plant	.....	1,500	Approximate yield 39.0% basic lubes and 60.0% gasoil.		

OPERATION HOW TO DO IT MAINTENANCE





Upper left—End view of tube buffing machine showing brush shafts adjustment detail. Above—Side view showing brush arrangement. Left—Sketch of pulley and belt arrangement for opposed rotation.

HOW TO—
Clean Condenser and Reboiler Tubes

A SHOP-FABRICATED buffing machine designed for removing scale and other deposits from used condenser and reboiler tubes has proven satisfactory in reconditioning operations at the Lake Charles butadiene plant of Cities Service Refining Corporation.

Six circular wire brushes are used in the machine and are mounted on four shafts, two brushes each on two of the shafts and one brush on each of the other shafts. The shafts are rotated by a belt and pulley assembly powered by an air motor. The shafts are connected so that each shaft rotates in opposite direction to the adjacent shafts. This balancing prevents the tubes from turning with the brushes, and assures positive cleaning action.

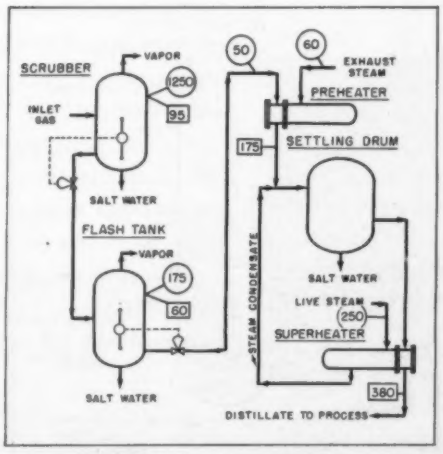
The shafts axes are slightly off horizontal, thus providing a pulling force that automatically feeds the tubes through the buffing machine. The opening through which the tubes are fed is adjustable to accommodate several sizes of tubing.

While the time required for the cleaning of a tube, of course, is dependent upon the quantity of scale to be removed, in comparison with hand cleaning a material saving in time and labor is achieved.

THE HOW OF
A Distillate Salt Water Separation System

THE PROBLEM of separating salt water and distillate before processing the distillate, was solved by the method shown in the flow diagram. In use in a gasoline plant located on the Gulf Coast area, the system has provided satisfactory operation without salt plugging and corrosion of heat exchange equipment.

Gas flows to the plant's inlet scrubber at about 1250 psig and 95° F. Distillate and salt water from the gas stream are collected in the scrubber, and some of the salt water drawn off the bottom of the scrubber. Gas overhead from the scrubber flows to the plant's absorbers. The distillate and remaining salt water flow under pressure to a flash tank where the distillate is flashed at 175 psig and an additional amount of salt water is drawn off from the bottom of the flash tank.



How distillate salt water separation system works.

Distillate and salt water from the flash tank flows through a preheater in which the stream is heated by exhaust steam from about 60° F. to approximately 175° F., and then flows into a large diameter settling drum. Before the stream enters the settling drum, however, it is mixed with the condensate exhausted from a steam superheater, as indicated in the diagram. The remaining salt water in the distillate is allowed sufficient time to settle to the bottom of the drum and is drawn off continuously by the operator.

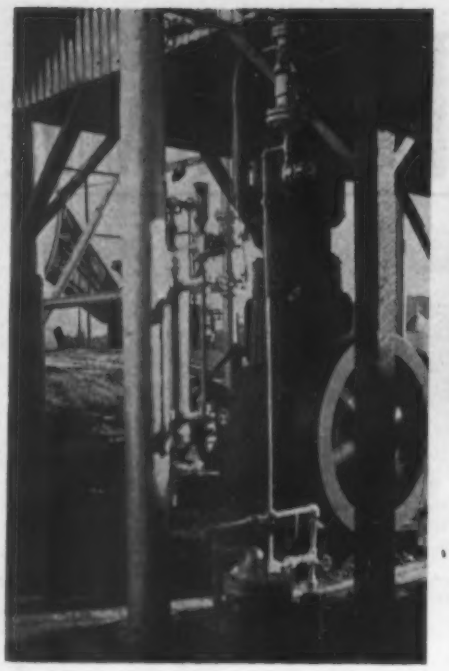
The salt-free distillate is passed through the superheater, which raises its temperature to 380° F. for further processing in the plant.

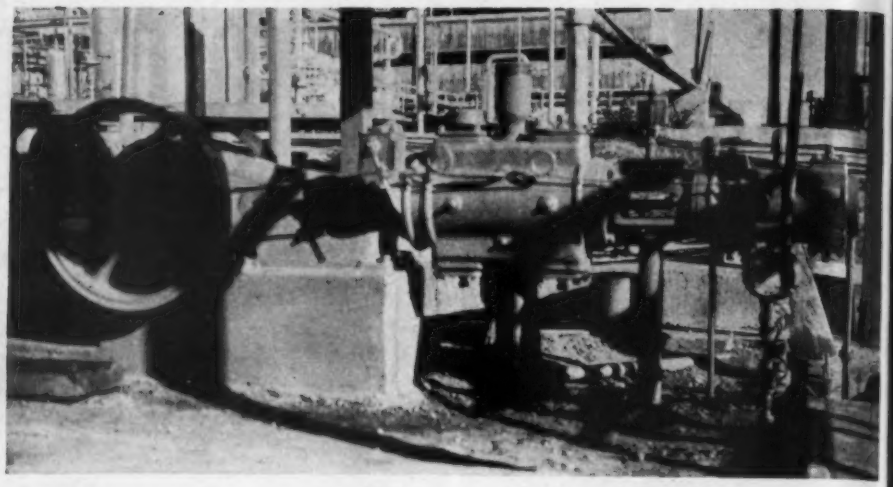
HOW—
Steam-Driven Compressor Unit Maintains Air Pressure

COMPRESSED air is essential in natural gasoline plants for various purposes, one of which is compressor engine starting. To assure an unfailing supply of air at starting pressure for large gas-engine driven compressors in one plant, the operator supplemented the conventional gas-gasoline driven air compressor unit with a continuously running steam-driven compressor unit. Unit is equipped with a control valve in the steam line actuated by a change in pressure in the compressed air volume tank.

The steam engine is a single-cylinder vertical type engine and has an extension shaft supported by a pillow-block on one end with the other end connected to the crankshaft. V-belts in multi-grooved sheaves transmit power to the compressor. An idler sheave, mounted in an A-frame that straddles the drive shaft and sheave and is bolted to the engine frame, maintains the required tension on the belts. The compressor is a tandem, two-stage unit operating with atmospheric intake and uncooled discharge to the high pressure cylinder.

Steam to the engine enters the steam





Left—Vertical steam engine and control valve which provides idling steam. Above—Tandem two-stage air compressor driven by vertical steam engine at left.

chest through a conventional throttle control, which is supplemented with a pressure actuated diaphragm valve set to admit enough steam to the engine, after the air pressure is built up to a predetermined level, to keep the engine running.

This method eliminates starting the engine by an operator when compressed air is being used, and prevents condensation of steam in the engine when it is idle. When air is withdrawn from the storage tank, the control valve opens to admit more steam and the engine picks up speed immediately. For several months the unit has not required attention other than routine lubricating checks.

HOW TO—

Protect Compressors With Vacuum Scrubber

THE scrubber shown in the accompanying diagram operates under vacuum in the suction line from field separators to the compressor in a natural gasoline plant, and was designed to provide maximum protection to the compressors from the entrained liquid in the gas stream. It contains a section, separate from the scrubber section, from which the liquid scrubbed from the gas is blown down to the plant condensate recovery system. The two sections were designed as a single vessel with the scrubber section above the liquid blowdown reservoir.

Incorporating the liquid reservoir and the scrubber in a single vessel eliminated foundations, anchor bolts, base rings, heads, plant space, connecting piping, and other material that would have been required for installation of two separate vessels. Also, the control system for the single vessel is somewhat simplified, since only one liquid level control instrument is required.

In operation, when both sections of the vessel are pressure equalized, the accumulation of liquid in the scrubber section causes it to overflow through the siphon line and check valve into the condensate section. If the liquid level in the scrubber rises above the siphon, a high level alarm warns the operator in time that liquid carryover to the compressors can be prevented.

When the liquid level in the condensate section of the scrubber in Figure 1 reaches a predetermined level, the liquid level control instrument actuates three valves—A, B, and C. Valves A and B, normally closed, are opened by the air pressure from the control instrument.

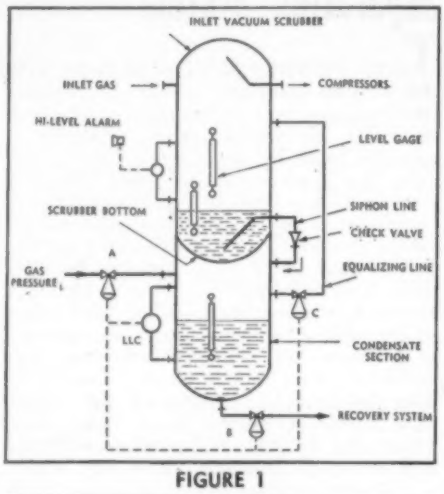


FIGURE 1

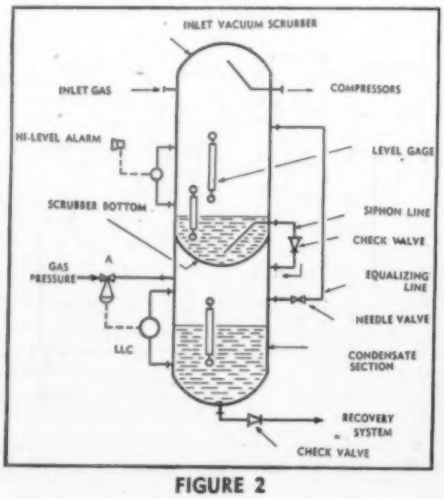


FIGURE 2

Valve A permits a flow of gas under pressure to blowdown the condensate section through Valve B to the waste condensate recovery system. Valve C, which is a small air-controlled valve in the equalizing line, about one-inch in diameter, normally open, is closed by the air pressure that opens A and B. Valve C permits gas to flow from the condensate section into the scrubber, equalizing pressure in the two sections.

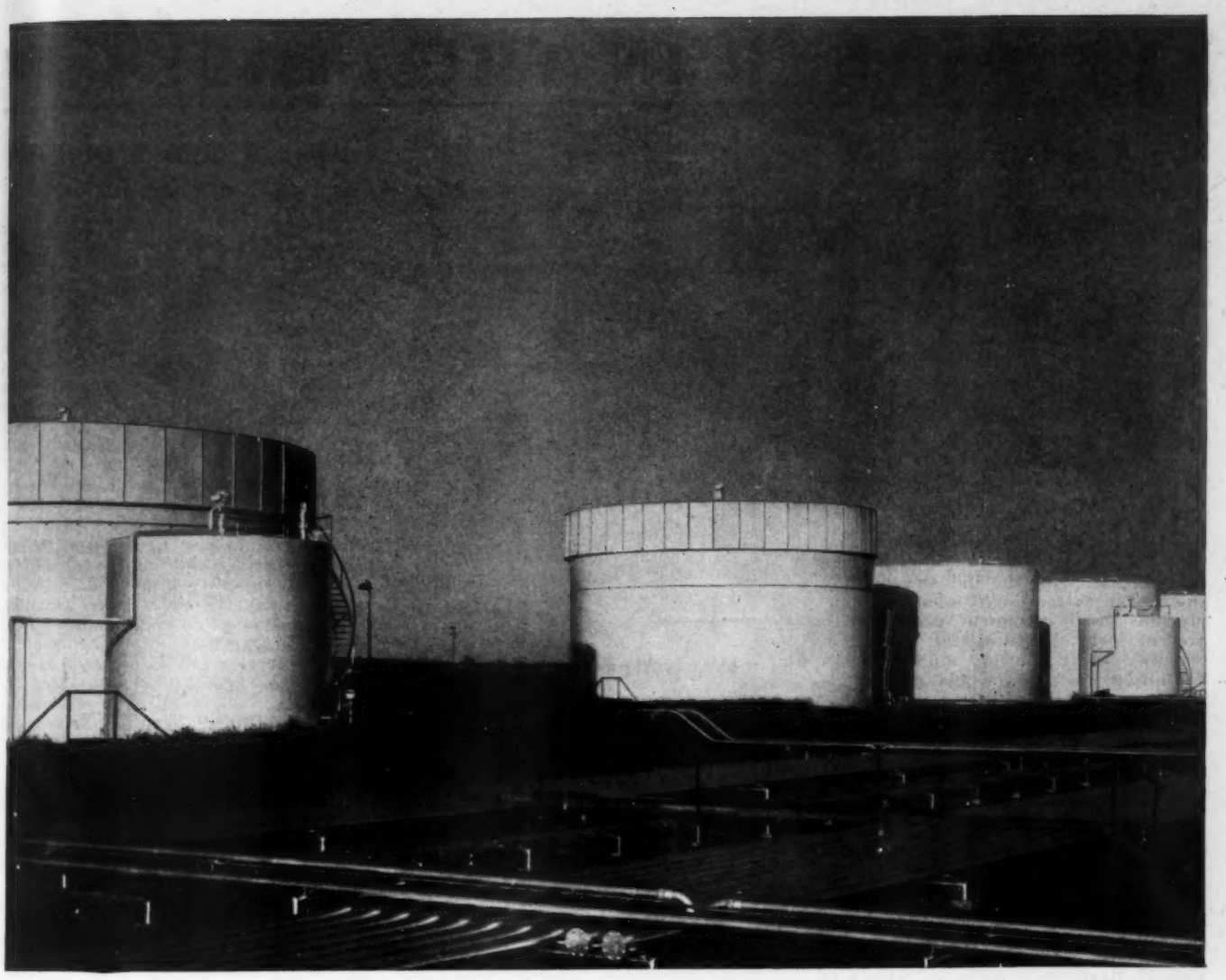
Figure 2 represents a variation in the control system used to blowdown the condensate section. Valve B is replaced by a check valve, and valve C by a needle or throttling valve, which is adjusted to bleed the gas admitted into the condensate section through valve A for blowdown into the scrubber section through the equalizing line.

HOW TO—

Provide Electrical Outlets

A MULTIPLE electrical service outlet manifold, fabricated of underwriter-approved fittings, has been found to facilitate maintenance operations on overhead installations by providing several outlets for the use of electrical powered equipment at levels where only one permanent outlet is provided.

The manifold consists of four explosion-proof service outlets wired in parallel with a feeder line for tie-in with the permanent outlet. The manifold assembly is mounted on a four legged standard which can be carried to any working level thus providing, with a minimum of cost, the same service as a like number of permanent outlets.



BALANCING ACT FOR HYDROCARBONS

When the volume pumped in exceeds the volume pumped out, there's danger of losing the most valuable part of your gasoline...the lighter fractions that mean superior performance in modern, high compression engines. The Expansion Roof Tank, either alone or manifolded to several cone roof tanks, acts as a balancing agent between the input and output rates and, in normal terminal operation, eliminates the possibility of filling losses.

This complete or near-complete elimination of filling losses is in addition to the absolute prevention of loss through standing or breathing. The Expansion Roof provides far more than the maximum volume required by vapor expansion due to temperature increases.

Available in a wide range of expansion capacities, the Expansion Roof is suited to most single or multiple tank storage facilities for production, refining, or marketing.

You'll find it profitable to investigate this balancing act for hydrocarbons when you plan increased storage equipment.

FABRICATED PLATE DIVISION

GRAVER TANK & MFG. CO., INC.

East Chicago, Indiana

Graver offers a complete service to the petroleum industry including Expansion Roof Tanks, Floating Roof Tanks and pressure vessels. In addition, Graver is prepared to furnish specialized steel plate work such as fractionating columns and class one vessels as well as stainless and alloy fabrication; water conditioning equipment of all types; and through the Graver Construction Co., is prepared to handle all types of petroleum and chemical construction work.

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NEW YORK • PHILADELPHIA • CHICAGO • CATASAUQUA, PA. • HOUSTON • SAND SPRINGS, OKLA.

THE MONTH IN THE INDUSTRY

Krug Report Opposed To Controls on Oil Industry

Interior Secretary Julius Krug informed the White House last month that while there may be local supply difficulties during the 12 months ahead, it is not anticipated that these will be sufficient to warrant imposition of government controls over supply and demand of petroleum.

This advice was contained in a report dated May 17, prepared by an Interior Department "fuel and power task committee," and made available in refuting recent published reports which depicted Krug as leading a second administration drive for authority to impose controls on oil.

In the report, Krug pointed out that with supply and demand in such close balance, and with the industry already engaged in extraordinary efforts to supply the small increment necessary to prevent local shortages, the imposition of government controls might have a disruptive effect that would make matters worse instead of better.

The report emphasized the oil industry's critical need of steel and said that its forecasts are predicated on reasonable adequate amounts being made available for drilling and expansion of facilities.

Six Scientists Selected For Humble Lecture Series

Six scientists from American Universities have been named by Humble Oil & Refining Company to conduct the 1948-49 Baytown lectures in science, a series of two-week courses designed to bring latest scientific information to research personnel at Humble's Baytown, Texas, refinery.

The men are Dr. R. L. Pigford, chairman, chemical engineering department, University of Delaware; Dr. J. W. McBain, professor of chemistry, Stanford University; Dr. B. F. Dodge, professor of chemical engineering, Yale; Dr. Henry Eyring, dean of the graduate school and professor of chemistry, University of Utah; Dr. Paul D. Bartlett, professor of organic chemistry, Harvard; and Dr. F. A. Matsen, professor of chemistry and physics, University of Texas.

Dr. Pigford will open the '48-'49 series July 19 to 30 with lectures on the mathematics of chemistry and chemical engineering. The 1947-48 science series closed June 14-25 with lectures by Dr. J. L. Hildebrand, professor of chemistry, University of California, on "Thermodynamics of Non-electrolytic Solutions."

New Research Center May Hasten Rubber Discoveries

A new, multi-million dollar research center which will "make it possible to bring scientific discoveries to maturity three or four times faster than at present" was inaugurated last month at Brecksville, Ohio, by The B. F. Goodrich Company.

In addition to probing into the mysteries of crude and man-made rubber, BFG will conduct intensive research in such fields as chemicals, plastics, agriculture, horticulture and the application of nuclear energy to rubber manufacturing. Atomic energy's usefulness and efforts in rubber and related materials will be studied.

The center comprises six buildings on a 261-acre site and supplants facilities that were in the heart of the home plant at nearby Akron.

Dr. Rossini Honored

Dr. Frederick D. Rossini, chief of the thermochemistry and hydrocarbons section of the National Bureau of Standards, was awarded an honorary Doctor of Science degree last month by the Carnegie Institute of Technology.

Dr. Rossini, a graduate of Carnegie, is the first alumnus ever to receive a C. I. T. honorary degree, and the presentation was the fifth honorary granted in the school's 48-year history.

Meetings

July

29—National Petroleum Council meeting, Department of Interior, Washington, D. C.

September

6-10—American Chemical Society, Division of Petroleum Chemistry, fall meeting, St. Louis.
13-17—Third Instrument Conference and Exhibit, Philadelphia, Convention Hall.
15-17—National Petroleum Assn., meeting, Atlantic City, Hotel Traymore.
16—API Lubrication Committee, Atlantic City, Hotel Traymore.
22-22—National Butane - Propane Association, Chicago.
27-28—Independent Petroleum Association of America, San Antonio, Plaza Hotel.

October

4- 9—American Gas Association Convention, Atlantic City, Ambassador and other hotels.
8—California Natural Gasoline Association, annual fall meeting, Los Angeles, Ambassador Hotel.
11-13—National Lubricating Grease Institute, annual convention, Chicago, Edgewater Beach Hotel.
12-16—National Chemical Exposition, Chicago, Coliseum.
14-15—Indiana Independent Petroleum Association, Indianapolis Hotel Severin.
14-15—Texas Mid-Continent Oil & Gas Association, Fort Worth.
15-16—American Oil Chemists Society, New York.
25-29—National Metal Congress and Exposition (American Society for Metals), Philadelphia.
23-29—American Society for Metals annual convention, Philadelphia, Benjamin Franklin Hotel.
25-28—Metals Institute Division AIME fall meeting, Philadelphia, Hotel Adelphia.
25-29—American Welding Society annual convention, Philadelphia, Bellevue-Stratford Hotel.

November

4- 5—Society of Automotive Engineers, Fuels-Lubricants Division, Tulsa, Mayo Hotel.
8- 9—API Lubrication Committee, Chicago, Stevens Hotel.
8-11—American Petroleum Institute, annual meeting, Chicago, Stevens Hotel.
28—to Dec. 3—American Society of Mechanical Engineers annual meet, New York.
29—to Dec. 4—18th National Exposition of Power and Mechanical Engineering, New York, Grand Central Palace.

Industry's Capital Outlay Continues at High Rate

Expenditures by oil companies for 1949 and 1950 will continue at the same rate or higher than the $4 billion spent in 1947 and 1948 for expansion and replacement, it was shown in Washington last month.

The House Commerce Committee on Petroleum Prices and Profits reported that it is concensus of industry that great need for these funds should and can be met only out of high earnings and that this need well justifies the current price level of petroleum.

Companies replying to the questionnaire sent by the committee included:

Atlantic Refining Company has about $28 million increase in net fixed assets planned during 1948 and probably at same rate in 1949 and 1950, provided steel and other materials are available, with expansion coming mainly from concurrent earnings.

Cities Service Oil Company reported construction in 1947 of about $96 million and a budget of $140 million for 1948, of which 43 percent will be financed from reserves and current earnings and 57 percent from borrowed capital.

Continental Oil Company expansion over the next three years is estimated at a total of $150 million.

Gulf Oil Company expects its expansion during the next three years will approximate at least $500 million.

Humble Oil & Refining Company has reported capital expenditures in 1948 at $133 million with expenditures for the next two years to continue at the same rate. Financing chiefly will be from earnings.

The Ohio Oil Company will spend between $50 and $75 million for expansion from earnings.

Richfield Oil Corporation budget for capital expenditures amounts to $18,382,810 for other than marketing facilities, which amounts to $30,101,000.

Shell Oil Company has estimated capital expenditures during 1948, 1949, and 1950 for expansion and replacements at $351,800,000 of which $136,850,000 is estimated for expansion.

Skelly Oil Company's replacement of existing facilities will require $30 to $40 million to come from earnings, and modernization and enlargement of facilities is expected to require $40 to $55 million if available earnings permit.

Standard Oil Company (Indiana) contemplates expenditures for 1948 of $220 million for a total of $600 million spent during 1946, 1947, and 1948. Although no estimate was made for the next two years, any further expansion must be financed largely out of earnings unless equity capital becomes available on a reasonable basis.

Standard Oil Company (Ohio) offered a current forecast for capital expenditures during 1948-50 of $112,470,000 with about 40 percent of this total provided by earnings.

New Wax Plant

A new $3.5 million wax plant at Richmond will be completed in September for Standard Oil Company of Califor-

THE MONTH . . .

plant was constructed at a cost of $100,000 and this was followed later that year by a new thermal cracking plant at a cost of $1.75 million.

The refinery is located in Burnaby, B. C., fronting on the upper reachers of Vancouver harbor.

Reconstruction in Burma Is Outlined by Chairman

Burmah Oil Company, Ltd., Glasgow, Scotland, is continuing its reconstruction program of oil production and refining facilities in Burma along four lines, Sir Kenneth Harper, company chairman, has announced. Plans include rebuilding the company's refinery, restarting crude production, rehabilitation of main pipe line from Burma fields to Rangoon, and rebuilding depots and other distribution facilities.

The scale of operation will be less than prewar, but subsequent expansion would be possible. Completion of the program is not expected until 1951.

Bolivia Refining Plant Work To Start In Fall

Construction of Yacimientos Petroliferos Fiscales Bolivianos' two refineries is expected to begin in the fall, plans calling for a crude unit at Sucre and topping and reforming facilities at Cochabamba, Bolivia. Engineering and processing design is being done by Foster Wheeler Corporation which will also supervise construction. Completion of the two refineries is scheduled for early 1950.

Camri crude will be charged to the crude unit at Cochabamba. This crude has a 63 percent yield of 47-octane naphtha which will be used as the reforming unit charge. Ultimate products of the Cochabamba refinery will include a 92-octane aviation gasoline, motor fuel, kerosine, diesel fuel, and a residual fuel oil.

New Jersey Township Re-Zones for Refinery

Plans for a new $100 million refinery at Woodbridge, N. J., by Shell Oil Company still lacks official company confirmation although Carl Barker, assistant to Shell president H. S. M. Burns, told township residents that the company had intentions of building there and was prepared to purchase private and public land for that purpose.

The township committee has re-zoned a tract of land to make possible build- of a refinery.

Skelly Enlarges Refinery Located at El Dorado

Additional expansion has been announced for the Skelly Oil Company refinery at El Dorado, Ark., which was recently expanded to handle 35,000 barrels per day catalytic cracking capacity. The new expansion will provide in excess of 45,000 barrels per day of refined products from the plant over the original 30,000 barrels per day.

Faull Named Laboratory Head California Research

Dr. R. F. Faull has been appointed to the newly-created position of manager of the La Habra, Calif., oil field research laboratory of California Research Corporation, a Standard Oil Company of California subsidiary.

Faull

At the same time, it was announced that the company's two oil field research units, at Whittier and La Habra, are being combined into one organization under Dr. Faull's direction, with headquarters at La Habra.

Assisting Dr. Faull will be Walter C. Dayhuff, who has been named technical assistant in charge of administrative functions and surface processing research, and Dr. M. B. Standing, division supervisor in charge of research on drilling and production.

Texaco-Pemex Contract Not Officially Concluded

The Texas Company late last month had made no official statement regarding its pending contract with Petroleos Mexicanos.

Pemex revealed that contract terms called for a loan by Texaco of $30 million for expansion of oil production in Mexico at a rate of 3 percent of 3 million barrels of oil a year until the loan plus interest are paid off. Technical advice and assistance in developing new wells would be supplied by Texaco.

19-Year Safety Record Gets Joseph Holmes Award

The Texas Pacific Coal and Oil Company was awarded the Joseph A. Holmes certificate of honor by the U. S. Bureau of Mines for the outstanding safety record achieved by the company's Gasoline Plant No. 3 located at Caddo, Texas. The plant has operated without a lost-time accident from August 29, 1929, to March 1, 1948, a total of 931,216 man hours over the 19-year period with an average of 22 employes.

The award was presented June 24 on behalf of the Joseph A. Holmes Safety Association by G. M. Kintz, supervising engineer for District G of the Bureau of Mines at a special meeting of T.P. officials and employes at Caddo.

Gets Argentine Contract

Catalytic Construction Company, Philadelphia, has announced receipt of contracts calling for the engineering and procurement of materials for two 25,000-barrels-daily crude topping units with auxiliary facilities for Argentina.

All materials for the YPF (Yacimientos Petroliferos Fiscales de la Argentine) will be shipped in the third quarter of 1948, it is anticipated. Contract will gross $2,500,000.

Ohio Standard Elects Two Vice Presidents

Hugh L. Patch and A. E. Wolf last month were named vice presidents of The Standard Oil Company (Ohio) and Ralph A. Martin elected controller of the company. Carl F. Jordan was appointed assistant vice president.

Patch will be vice president in charge of accounting; Wolf vice president in charge of finance; and Jordan assistant vice president reporting to the newly-elected executive vice president, Clyde T. Foster.

Neal Is Named Manager Of Glenn McCarthy Plants

Hugh A. Neal has been named manager of the two plants, located at Winnie, Texas, of Absorption Plant, Inc., and McCarthy Chemical Company. Leon Dorsey was named production superintendent and E. E. Holden was named maintenance and construction superintendent of both plants.

Prior to joining the Glenn McCarthy interests, Neal was employed by Phillips Petroleum Company in Bartlesville, Okla. He also worked in the Rock Island Refinery in Duncan, Oklahoma, and was with the Franklin Oil Company.

Dorsey, a graduate of the University

Trends of Operations and Changes in Stocks

Figures on crude stocks are from Bureau of Mines weekly reports; all others from American Petroleum Institute weekly reports, which are estimates on Bureau of Mines basis.

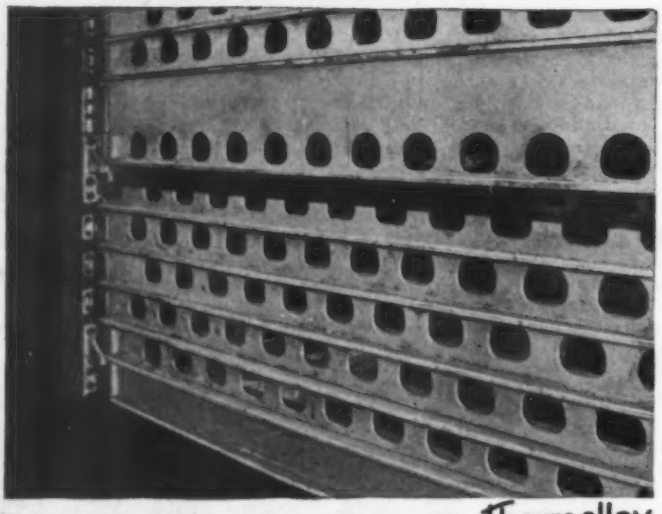
(All figures in thousands of barrels—add 000)

Trends in Week Ended	Crude Oil			Gasoline		Gasoil and Distillate		Residual Fuel	
	Production Daily	Runs to Stills Daily	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End
1947:									
January 25	4,672	4,820	221,655	14,624	99,801	5,630	50,257	8,224	48,558
February 22	4,786	4,860	224,580	14,668	103,904	5,929	40,739	9,332	44,919
March 29	4,865	4,843	225,720	14,396	107,576	5,969	32,737	8,668	43,364
April 26	4,930	4,725	234,051	14,213	103,860	5,435	32,286	8,186	42,668
May 31	5,024	5,000	239,370	14,709	95,867	5,732	36,032	8,910	45,224
June 28	5,109	5,093	236,221	16,070	91,806	5,606	41,721	8,298	48,490
July 26	5,084	5,162	231,357	16,142	85,812	5,708	47,097	8,738	52,497
August 30	5,157	5,209	228,281	16,753	84,105	5,919	54,808	8,962	55,242
September 27	5,196	5,290	224,994	16,501	82,472	6,136	60,406	8,580	56,777
October 25	5,295	5,165	224,308	16,529	82,003	6,638	62,609	8,666	57,419
November 29	5,257	5,309	224,540	16,667	86,319	6,382	61,988	8,405	56,747
December 27	5,285	5,543	222,770	17,013	91,269	7,041	50,324	9,698	51,896
1948:									
January 31	5,318	5,434	221,663	15,986	102,973	7,690	40,580	9,141	50,839
February 28	5,387	5,463	220,507	15,796	111,040	7,963	33,836	8,824	49,206
March 27	5,377	5,324	222,814	15,783	112,991	7,652	30,717	8,554	48,334
April 24	5,415	5,517	221,652	16,515	111,128	6,831	34,237	8,877	49,572
May 29	5,452	5,715	221,703	17,827	107,185	7,054	38,641	9,508	55,146
June 26	5,494	5,674	*222,321	17,938	104,178	7,200	45,166	8,858	58,812

* June 19.

Thermalloy Tube Supports

. . . Lower Operating Costs



For Lower Operating Costs, Specify Thermalloy

- Tube sheets
- Drum liners
- Burner nozzles
- Pump parts

You can't turn in low operating costs with unnecessary tube support replacements. And it isn't the initial cost of a tube support that determines its value. It's the cost per hour on the job—the *reduced* replacement cost—that counts.

Right there—more operating hours—is where refiners are proving the unsurpassed value of Thermalloy tube supports.

The added service you get from Thermalloy tube supports is due to the high physical properties of Thermalloy, which retain maximum strength at elevated temperatures, and its high resistance to corrosive gases. Both of these characteristics spell longer life in service and fewer replacements.

Thermalloy tube supports are now being used in refineries all over the world. They can be supplied for use at temperatures up to 2100° F. It will pay you to get complete information about Thermalloy tube supports. They can cut your operating costs and save you money in the long run.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO

THE MONTH . . .

of Texas, has been process engineer at the Absorption plant since 1945, after having worked at Old Ocean for J. S. Abercrombie and prior to that for Gulf Oil Company, Port Arthur.

Holden was assistant superintendent of maintenance and construction with Dow Chemical Company for seven years and was also with R. P. Farnsworth Company before joining McCarthy 1½ years ago.

The new chemical plant will be opened shortly. Work has started on a second unit of the absorption plant which will double its present capacity.

UOP Fractionating First Tank of Shale Oil

A railroad tank car of 6369 gallons of crude shale oil—the first bulk shipment of oil from the Bureau of Mines' new oil shale demonstration plant near Rifle, Colo.—is undergoing preliminary laboratory tests.

The shale oil will be fractionated or separated into the various grades by Universal Oil Products Company at Riverside, Ill., after which Union Oil Company of California will conduct cracking and other refining studies in its California laboratories.

The Bureau's oil shale demonstration plant, a part of the long-range $60,000,000 synthetic fuels research and demonstration program, has been in operation several months. Shale is mined in the cliffs of Anvil Points, near Rifle, Colo., transported down a mountainside road and the oil is extracted in retorts at the demonstration plant on a nearby plateau.

Admiral Miller Named API Information Head

Rear Admiral Harold Blaine Miller, USN (ret.) last month was appointed director of the Department of Information of the American Petroleum Institute.

Miller

Formerly public relations officer for Fleet Admiral Nimitz in the Pacific Ocean Area, Miller later was assigned to the Navy Department in Washington as Director of Public Information. Upon his retirement in 1946, Miller became vice president, public relations, for Trans World Airline. Following this he served as executive director of the Congressional Aviation Policy Board.

In addition to functioning as API's director of information, Miller will, by request of the Oil Industry Information Committee, of which Ralph C. Champlin, of Ethyl Corporation, is chairman, serve as executive officer of that Committee.

Robert E. Allen will continue with API as assistant director of the Department of Information.

Sunray Sets Record for Thermal Cracking Unit

A new record has been established for the longest continuous run by a thermal cracking unit. The record is 170 days 22 hours and the plant is a three-coil Dubbs unit at Sunray Oil Corporation's Allen, Okla., refinery.

The run was ended April 29 when the plant was voluntarily shut down for routine cleanout and inspection. The unit consists of a light oil heater, an intermediate oil heater, a heavy oil heater, two reaction chambers, a flash drum, and fractionation and stabilization equipment. Recycle ratios for recirculation of hot oil are around three-to-one for each coil based on fresh feed of corresponding boiling ranges.

While establishing the record run, the unit processed 1,373,675 barrels of charging stock, an average of 8037 barrels daily.

Clean-out period after the long run required 6 days, well within the usual 4 to 10 days normally used for this work. A rigid inspection was conducted, necessary maintenance operations performed, extensive testing completed, and the unit returned to service, in less than a week.

The operating crew are talking now about January 1, 1949, as a suitable terminal date for this new run.

View of towers of the three-coil Dubbs thermal cracking unit at Sunray Oil Corporation's Allen, Okla., refinery.

Viscosity Standards Available From API

Restandardization of the three API viscosity standards has been completed, the standards being available for calibration of both kinematic and Saybolt viscosimeters. The approximate viscosities of the viscosity standards are as follows:

DESIGNATION OF STANDARD	SAYBOLT UNIV. VISC. (SEC.)			SAYBOLT FUROL VISC. (SEC.)	KINEMATIC VISC. (cs)		
	—40° F.	100° F.	210° F.	122° F.	—40° F.	100° F.	210° F.
Alpha 48	...	304	52	...	...	66	8
Beta 48	...	928	116	92	...	417	24
Gamma 48	341	136	...	...	75	3	...

These standards are available as a service to industry and certified exact values are furnished with each shipment.

The oils may be obtained in 8-ounce containers, $2.50 each, and in 1-quart containers, $5 each. Address Lacey Walker, secretary, American Petroleum Institute, 50 West 50th St., New York 20. Remittance with the order is requested. Shipment will be made by express, collect, to points within the United States unless otherwise specified by the purchaser. Method of shipment must be specified and charges paid by purchaser ordering these standards for shipment outside the United States.

C. D. Lowry, Jr., Named To Head Research Panel

Dr. Vannevar Bush, chairman of the Research and Development Board, National Military Establishment, last month appointed Dr. C. D. Lowry, Jr., of the staff of Universal Oil Products Company, as executive director of the board's panel on petroleum. Dr. Lowry, an organic chemist, has been connected with UOP for more than 20 years.

The Panel on Petroleum assists in carrying out the functions of the Research and Development Board in the field of petroleum, coordinating service research both with reference to petroleum products and their utilization and also containers and handling equipment.

Ernest H. Peabody Given Honorary Doctor Degree

Ernest H. Peabody, president of Peabody Engineering Corporation, received the degree of Doctor of Engineering, Honoris Causa, from Stevens Institute of Technology at the June commencement exercises.

Peabody

Dr. Peabody, active for many years in the development and perfection of combustion equipment, introduced the first combined oil and gas burner that permitted the economical and efficient burning of either gas or oil or both fuels together. In addition, he invented and

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- Hand operated or remote control speed changer —
- High exhaust pressure trip, or remote control electrical trip, actuating emergency trip valve —
- Throttling type emergency trip valve for hand throttling —
- Gland seal piping for condensing operation —
- Gland sealing for operation with gas —

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perfected wide-range mechanical atomizing fuel-oil burner, the combined pulverized coal and oil burner and later produced the first combined burner for liquid, gases, and pulverized fuels.

Dr. Peabody holds some 30 patents. He is a member of the American Society of Mechanical Engineers, and Society of Naval Architects and Marine Engineers.

Dr. Peabody began his career in combustion engineering with The Babcock & Wilcox Company, where he worked for 29 years as drafstman, erector, engineer of tests, research man, inventor, and sales-engineer. He founded his own firm at the age of 51, and is still active in heading up management and research on new developments.

Presently, his firm is carrying out research for the U. S. Navy and an airplane gas turbine manufacturer in furnace design and combustion.

Instrument Courses Are Now in Thirteenth Year

The Foxboro Company, which has conducted training courses in the theory, application, operation and maintenance of industrial instruments since early in 1935, has announced its schedule for the remainder of 1948. There will be five courses, each of two weeks' duration, in the months of July, August, October, November and December. Courses will also be arranged for companies wishing to send a group sufficiently large to warrant a special class for the study of particular instruments and applications. Special courses will also be arranged for specific industry groups.

Enrollment is by application. Address the Director of Training Courses.

Gasoline Plant Given for Recovery Plan Use

Cities Service Oil Company is contributing its present natural gasoline plant in the North Cowden field, West Texas, and a group of operators will expand it in a conservation program which it is estimated will increase the amount of oil from this field by 50 percent.

The cooperative plan in which about 80 percent of the acreage in this Ector and Andrews counties oil field have joined, calls for an extensive gas-injection program. Casinghead gas produced from the Grayburg formation will be processed in the plant to recover natural gasoline and other liquid hydrocarbons. Residue gas will be compressed and injected into the producing formation.

Fire Closes Aetna Plant

As a result of a fire which damaged the process tank farm, Aetna Refining Company's 8000-barrel per day refinery at Louisville, Ky., was closed late in June for an indefinite period for repairs. The fire seemed to be confined to intermediate tanks for temporary storage of products being transferred from one refinery unit to another. Process equipment itself appeared to suffer only minor damage.

Vegh Garzon Named UOP Latin American Consultant

Universal Oil Products Company has appointed C. R. Végh Garzón of Montevideo, Uruguay, as consultant in Latin America. Végh Garzón, who founded the South American Petroleum Institute (ISAP), has served since 1940 as president of the Uruguayan section and chairman of the International Council. He has represented Uruguay at numerous international scientific congresses.

Vegh Garzon

Végh Garzón was chief engineer and later, general manager of ANCAP during the period when the petroleum refinery was erected which supplies the liquid fuel requirements of Uruguay. In this association he directed the purchase of all equipment and supplies from Great Britain and the United States.

Although continuing to act as technical petroleum advisor to ANCAP, Végh Garzón has served, in private capacity, on the board of directors of various industrial companies. In 1946 he became technical and commercial adviser to the "Refinaria de Petroleos do Distrito Federal S.A." for the construction of a petroleum refinery in Rio de Janeiro. He received his engineering degree from the University of Montevideo in 1926.

Allen Is New President of California Refining Company

C. E. Allen has succeeded Fred Powell as president and director of California Refining Company, Standard Oil Company of California affiliate. Allen has been with the parent company for the past 17 years.

Powell will become general manager of Socal's El Segundo, Calif., refinery.

Winter Fuel Oil Supply Appears Much Improved

The supply of fuel oil for next winter's demand appears better than that of last year, the Senate Commerce Oil Subcommittee reported last month. Major oil company representatives predicted a brighter supply-demand outlook and drew praise from committee members for the oil industry's efforts when supplies were scarce last winter.

L. S. Wescoat Heads API Nominating Committee

L. S. Wescoat, The Pure Oil Company, is chairman of the new API committee on nomination, which in November will present nominations for API officers and committeemen for 1949. The nominating committee also includes James A. Dunn, Barnsdall Oil Company, New York; Eugene Holman, Standard Oil Company of New Jersey, New York; William F. Humphrey, Tide Water Associated Oil Company, San Francisco; H. L. Hunt, Dallas; H. T. Klein, The Texas Company, New York; Charles F. Roeser, Roeser and Pendleton, Fort Worth; W. C. Skelly, Skelly Oil Company, Tulsa; R. S. Stoner, Standard Oil Company of California, San Francisco; S. A. Swensrud, Gulf Oil Corporation, Pittsburg, and A. E. Watts, Sinclair Oil Corporation, New York.

Officers to be nominated and elected are the president, four vice presidents, treasurer, secretary, assistant treasurer, and 24 members of the executive committee. All API members may make suggestions for nomination.

Credit to Monsanto

Credit which should have been given to Monsanto Chemical Company for certain data in a safety article used in the March issue of PETROLEUM REFINER was inadvertently omitted by the editors.

This was in Holland Howell's "Management and Employes See Safety Program Pay Off" where Monsanto should have been credited with the chart used on page 76 and also for the basic principles of the statutes and by-laws used on page 77.

Peterson Vice President

E. R. Peterson has been appointed a vice president of Standard Oil Company of California. He joined the company in 1923 and was in the marketing department until 1936, when he was attached to the executive staff as a general assistant. For the past several years he has been secretary to the executive committee.

Sohio Elects

The board of directors of Standard Oil Company (Ohio) has promoted Hugh L. Patch from controller to vice president in charge of accounting; and A. E. Wolf from assistant to president; W. T. Holliday to vice president in charge of finance. Carl F. Jordan, budget department head, has been appointed assistant vice president.

Berry Asphalt Moves

Berry Asphalt Company has announced removal of its main offices to Magnolia, Ark., from Chicago.

R. W. Francis and Jim Van Pelt will continue to represent Berry Lubricating oil sales from offices at 120 S. LaSalle St., Chicago.

Conoco Buys Plant

Continental Oil Company last month bought for $175,000 the toluene plant erected at Ponca City, Okla., during the war by the Defense Plant Corporation.

Completed in September, 1943, the plant was first used to manufacture nitration grade toluene and later was converted to produce toluene as a blending agent for 100-octane aviation gasoline. The plant was closed in July, 1945, and remained inactive until latter part of 1946 when it was leased by Continental to be used periodically for the manufacture of gasoline and other products.

Diwoky Given Important Post at Whiting Plant

Roy J. Diwoky has been promoted to assistant general superintendent of the Whiting, Ind., refinery of Standard Oil Company (Indiana). Diwoky joined the company in 1935 as a member of the technical service staff of the research department at the Whiting laboratory,

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where he became a group leader in 1939. In 1940 he was transferred to the manufacturing department at the Whiting refinery as assistant general foreman of pressure stills in the light oils division. After becoming technical assistant to the executive manufacturing staff in the general office at Chicago in 1943 and assistant superintendent of the light oils division at Whiting in 1945, he was appointed superintendent of the Whiting projects division in 1947.

A native of Council Bluffs, Ia., Diwoky received his B.S. and M.S. degrees in chemical engineering at the University of Iowa. He is a member of the American Chemical Society and the American Institute of Chemical Engineers.

Crandall Given Post

Kenneth H. Crandall, vice chairman of the board of The California Company, has been elected a director of Standard Oil Company of Texas. Both companies are subsidiaries of Standard Oil Company of California.

Crandall joined the California Company in 1925, was elected director and president in 1945, and last year became vice chairman of the board.

Leedy Named Director

Dr. Haldon A. Leedy, acting director of Armour Research Foundation of Illinois Institute of Technology, has been named director. He became acting director when Dr. Jesse E. Hobson resigned to become director of the Stanford Research Institute.

Olinger Superintendent

H. J. Olinger has been appointed plant superintendent of Stanolind Oil and Gas Company's Luby natural gasoline plant at Bishop, Texas. Olinger was formerly an operating engineer in the company's general office in Tulsa.

Gilman Resigns Post

Don E. Gilman, executive vice president of the Western Oil & Gas Association since 1944 has resigned. Gilman will continue to serve until a successor is named.

Happel Joins NYU

Dr. John Happel has joined the Chemical Engineering Department of New York University College of Engineering as professor of chemical engineering and will assume his duties September 1.

Happel

Dr. Happel received his bachelor of science degree from Massachusetts Institute of Technology in 1929, a masters degree in 1930, and last month a doctor of chemical engineering degree.

Dr. Happel has been associated with Socony-Vacuum Oil Company for the past 18 years and during the war he served on the technical advisory committee of the Petroleum Industry War Council. He is a member of several technical associations and societies.

Koppers, Gulf Join in Research

Gulf Oil Corporation and Koppers Company, Inc., last month announced signing an agreement under which the two companies will engage in cooperative research and development of processes for the conversion of coal to gas and liquid fuels. Work under the cooperative research program already has started.

"Koppers and Gulf believe that the nation's important synthetic liquid fuels program can be materially aided by combining the know-how and patent processes already developed by each in separate research," a joint statement said.

Both companies have been working for some time independently on matters associated with the production of synthetic liquid fuels. Koppers' research department has developed and patented several improved processes for commercial production of synthesis gas. Its engineering and construction division is building the government's $4.5 million synthetic liquid fuels demonstration plant at Louisiana, Mo. The plant will use the Fischer-Tropsch process.

Gulf Research and Development Company, Gulf subsidiary, has laboratories at Harmarville, Pa., and several Gulf laboratories in other parts of the country have been working for some time on various phases of synthetic liquid fuel production.

Under the Gulf-Koppers agreement, the cooperative program may lead to establishment of pilot plant facilities.

Ring Again Elected Head Of Penn Grade Association

D. T. Ring, Preston Oil Company, Columbus, Ohio, was re-elected president for his third term and five new directors were elected to the board of the Pennsylvania Grade Crude Oil Association at its annual meeting held last month in Pittsburgh. All other officers were re-elected.

The five new directors are George H. Daggett, president Bradford District Pennsylvania Oil Producers Association; W. Wayne Fensmyer of Minard Run Oil Company, and R. A. Keck of Kendall Refining Company, all of Bradford, Pa.; H. I. Johnston of Freedom-Valvoline Oil Company, Freedom, Pa.; and John Schmidt of Tiona Petroleum Company, Philadelphia.

R. A. Cattell, chief of the U. S. Bureau of Mines, petroleum and natural gas branch, predicted that synthetic liquid fuels will supplement petroleum products rather than replace them and that changes will come gradually.

Fayette B. Dow of Washington, D. C., general counsel, told members that aid of the courts is being invoked to protect the public in its purchase of Pennsylvania lubricating oils Dow cited methods used to make the public believe it is getting Pennsylvania oil when actually it is getting something else and said the association is preparing cases to submit to the courts and to the Federal Trade Commission to halt these deceptive practices.

Kidd Named Vice President

Robert L. Kidd last month was elected a vice president of Cities Service Oil Company (Delaware). With the company nearly 25 years, Kidd is a member of the board of directors and manager of the company's land and geological division. He also is a director of Cities Production Corporation.

Todd Nominated by ASME

James M. Todd, New Orleans consulting engineer, has been nominated as the next president of The American Society of Mechanical Engineers. Nomination is tantamount to election. The 1948-49 term will begin at the end of the Annual Meeting next December. Todd would succeed E. G. Bailey of New York.

Thirty-Seven Speakers at A. & I. 1948 Short Course

A total of 37 speakers and instructors from seven states addressed a record attendance at the third annual short course in natural gas technology, June 2, 3, and 4 at Texas A. & I. College, Kingsville. Official registration of more than 250 natural gas industry personnel represented 13 southern states. The course is offered annually by the engineering department of the college under the sponsorship of the Southern Gas Association.

Current problems in the production, transmission, and utilization of natural gas were the subject of the various courses. These stressed recent accomplishments in overcoming problems that are encountered in present day operations.

Elk Heater Completed

Elk Refining Company has recently completed and put into operation a 5000-barrel daily crude heater at their Falling Rock, W. Va. refinery. Alcorn Combustion Company were designers and engineers on the $35,000 project.

Carney Joins Warren

Bernard R. Carney has been appointed manager of the gas division of Warren Petroleum Corporation with headquarters in Tulsa. He formerly was assistant to the president of Shamrock Oil and Gas Company in Amarillo, Texas.

Seth Hunt Dies

Seth B. Hunt, 76, who rose from tank wagon driver in 1894 to retire as vice president and treasurer of Standard Oil Company (New Jersey), died June 22 after an illness of six months. He retired in 1933.

Sunray Plant On Stream

After testing, the 20,000-barrel a day fluid catalytic cracking unit at Sunray Oil Corporation's refinery, Duncan, Okla., went on stream last month. The plant, recently purchased from WAA, has been completely remodeled and includes complete topping and catalytic cracking operations, a 10,000-barrel vacuum unit, etc.

W. D. Manz is manager of the plant and R. L. (Dick) Johnson is superintendent. R. C. Underwood has been named assistant superintendent and E. C. Smith is maintenance superintendent.

SCIENCE *and* TECHNOLOGY ABSTRACTS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by The Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

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Fundamental Physical and Chemical Data

Vapor Pressure-Temperature Relationships Among the Branched Paraffin Hydrocarbons. H. WIENER, *J. Phys. & Colloid Chem.* **52** (1948) pp. 425-30.

An equation is given for calculating the boiling points of the branched-chain alkanes at pressures from 57 to 780 mm. of mercury. The constants of the equation are given by simple logarithmic functions of the pressure. The constants A and B of the Antoine equation, for branched-chained alkanes, are related by equations of similar form. When the constant C of the equation is evaluated from the normal boiling point, the average deviation between observed and calculated boiling points was ± 0.17° C.

Heats, Equilibrium Constants, and Free Energies of Formation of the Alkylcyclopentanes and Alkylcyclohexanes. John E. KILPATRICK, HELENE G. WERNER, CHARLES W. BECKETT, KENNETH S. PITZER, AND FREDERICK D. ROSSINI, *J. Research Natl. Bur. Standards* **39** (1947) pp. 523-43. (Research Paper No. 1845.)

Values of the thermodynamic properties to 1500° K. are presented for cyclopentane, cyclohexane, the normal alkylcyclopentanes, and the normal alkylcyclohexanes (to alkyl $C_{16}H_{33}$). The properties covered are heat-content function, the free-energy function, the entropy, the heat content, the heat capacity, the heat of formation from the elements, the free energy of formation from the elements and the log of the equil. const. of formation from the elements. For the following reactions equilibrium constants are given in graphic form: cyclization of normal paraffins to *n*-alkylcyclopentanes, cyclization of *n*-paraffins to *n*-alkylcyclohexanes, cyclization of 1-olefins to *n*-alkylcyclopentanes, cyclization of 1-olefins to *n*-alkylcyclohexanes, hydrogenation of *n*-alkylbenzenes to *n*-alkylcyclopentanes, hydrogenation of *n*-alkylbenzenes to *n*-alkylcyclohexanes, and conversion of *n*-alkylcyclohexanes to *n*-alkylcyclopentanes. The equilibrium between ethylcyclohexanes and the isomeric dimethylcyclohexanes is tabulated.

Methane - n - Butane - Water System in Two- and Three-Phase Regions. JOHN J. MCKETTA, JR. AND DONALD L. KATZ, *Ind. Eng. Chem.* **40** (1948) pp. 853-63.

The compositions and specific volumes of the co-existing phases of the methane - *n* - butane-water system were determined experimentally in the two-phase and three-phase regions at temperatures of 100, 160, 220 and 280° F. and pressures up to 3000 pounds per square inch absolute. The distribution of the three components between the phases can be used to predict the water content of hydrocarbon phases and the solubility of gases in water. The presence of water in the methane-*n*-butane system shifts the composition of the dew point mixture at a given temperature and pressure by as much as 8 percent. Equilibrium constants relating the concentration ratios between the several phases are presented. The data are presented in detail in seven tables and 17 figures. Includes bibliography of 50 references.

The Heat Capacity, Heat of Fusion and Entropy of Benzene. GEORGE D. OLIVER, MARGARET EATON AND HUGH M. HUFFMAN, *Jour. Am. Chem. Soc.* **70** (1948) pp. 1502-5.

The heat capacity of benzene was measured in the temperature range 12 to 341° K. From these and other data the entropy of the liquid and vapor at 298.16 and 353.26° K. were calculated. Experimental values of the entropy were found in good agreement with those calculated from spectroscopic and molecular data. The data secured in the course of the work are presented in tabular and graphical form and a bibliography of 14 references is included.

Table and Mollier Chart of the Thermodynamic Properties of 1,3-Butadiene. CYRIL H. MEYERS, CARL S. CRAGOE, AND EUGENE F. MUELLER, *J. Research Natl. Bur. Standards* **39** (1947) pp. 507-21. (Research Paper No. 1844.)

The thermodynamic properties of 1,3-butadiene are tabulated from —164° F. to 288° F. A Mollier diagram is given covering the pressure range of 3 to 300 psi. and the enthalpy range of 180 to 520 Btu per pound. The enthalpy of 1,3-butadiene, C_p for gaseous 1,3-butadiene, and the P-V-T relationship for gaseous 1,3-butadiene are also included.

Thermodynamic Properties of Hydrogen Sulfide. JAMES R. WEST, *Chem. Eng. Progress* **44** (1948) pp. 287-92.

The author presents a tabulation of the thermodynamic properties of hydrogen sulfide under various conditions of temperature and pressure. Tables are given for the properties of saturated hydrogen sulfide and for those of superheated hydrogen sulfide. Properties are also presented in graphical form as a Mollier chart. The heat, standard free energy and entropy of formation of hydrogen sulfide both from gaseous and rhombic sulfur and from gaseous hydrogen and diatomic sulfur vapor were calculated and are presented in tabular form. A bibliography of 24 references is included.

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Registry.

3-Methylphenanthrene
2-Methylphenanthrene
Tetrahydroanthracene
2,4-Dimethylheptane
2,3-Dimethylheptane
Octanedione-3,6
1,10-Decane dicarboxylic acid
1,12-Dodecane dicarboxylic acid
1,14-Tetradecane dicarboxylic acid
1,16-Hexadecane dicarboxylic acid
1,18-Octadecane dicarboxylic acid
Decanedione-4,7 or 3,6
4-Phenylisocrotonic acid
Phloroglucitol
Quinitol
2,2'-Dimercaptodiethyl ether
Mercaptosuccinic acid
Decahydro-α-naphthol
1-Vinyl-1,3-cyclohexadiene
Phenylisoxazoles

Chemical Composition and Reactions

The Structure and Properties of Ethylene Polymers. R. B. RICHARDS, *Jour. Inst. of Petroleum* **34** (1948) pp. 237-54.

It is believed that the polymerization of ethylene is initiated by free radicals. The function of the catalyst is to provide the free radicals. The variations in the properties of ethylene polymers are largely caused by variations in molecular weight. Polymers of molecular weight below 500 are oils or soft greases. Products with molecular weight from 1000 to 5000 are stiff greases or waxes. Those in the 8000 to 18,000 range are plastics that melt to a viscous liquid. The products of 25,000 and over molecular weight change to a rubbery condition on heating, but remain flexible at temperatures as low as —100° C. Typical viscosities for different molecular

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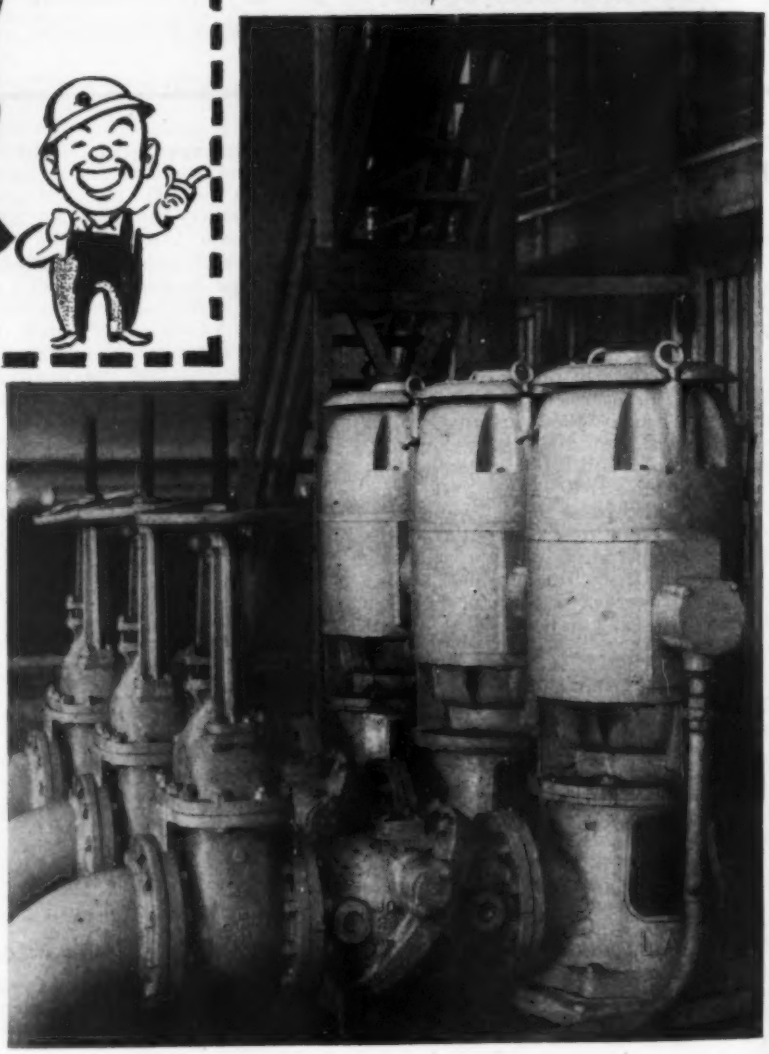

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weights are tabulated. The subject of the crystallization of waxes and of polymers is discussed. In solid polythene the proportion of crystalline material in average samples remains steady at about 70 percent. The relation between crystallinity, average molecular weight and physical properties of ethylene polymers is illustrated by a diagram. Inclusion of other monomers or of chemical groups, as for example, chlorine, in general produces softening and reduction in hardness. This is because of the inability of molecules of the second components to crystallize in the polymer structure. However, there are exceptions for ethylene can be interpolymerized with carbon monoxide to form a polyketone, the melting point and hardness of which are affected little by the proportion of carbonyl group in the product.

Reaction of Hydrogen Atoms With Butadiene. W. H. WHITE AND C. A. WINKLER, *Can. J. Research (B)* **26** (1948) pp. 3-6.

A study was made of the reaction of hydrogen atoms with butadiene at 28° to 252° C. The main product was ethane, with butane, butene, propane, and methane present in small quantities. Trace amounts of propylene and acetylene were also formed. Temperature had a small effect on the nature and on the relative proportions of the products. Typical reactions are suggested. An explanation is offered of why the nature and relative proportions of the products may be practically independent of temperatures.

Alkylation of Thiophene With Olefins. W. G. APPLEBY, A. F. SARTOR, S. H. LEE, JR., AND S. W. KAPRANOS, *Jour. Am. Chem. Soc.* **70** (1948) pp. 1552-5.

Alkylthiophenes were prepared by the direct alkylation of thiophene with isobutylene and propylene over a phosphoric acid polymerization catalyst. Alkylation was predominantly in the 2-position, although remarkably high yields of the 3-isomer were obtained. Physical properties and absorption spectra of several of the alkylthiophenes were determined. These are presented in tabular form. A study was made of the influence of several reaction variables on the alkylation with isobutylene.

Substitution and Polymerization Reactions of Thiophen and the Isomeric Thiophthens. JOSEPH BRUCE, FREDERICK CHALLENGER, HARRY B. GIBSON, AND WILFRID E. ALLENBY, *Jour. Inst. of Petroleum* **34** (1948) pp. 226-35.

Thiophen was polymerized by anhydrous ferric and stannic chlorides giving amorphous solids that were not freed completely from the polymerizing agent. Solid thiophthen gives dibromo-, di-iodo-, and dinitro-derivatives. The halogenation was accompanied by formation of polymers, which give a blue colour with sulphuric acid. Similar polymers are produced with hydrogen bromide or syrupy phosphoric acid in glacial acetic acid with sodium hypobromite and hydrochloric acid and as by-products in the preparation of thiophthenyl alkyl ketones by the Friedel-Crafts reaction using stannic chloride as catalyst.

The corresponding polymers from liquid thiophthen give a deep red colour with sulphuric acid and in benzene solution a magneta-coloured loose addition product with mercuric chloride.

Isomeric dithienyls are contained in the higher boiling fractions obtained in the preparation of the thiophthens from acetylene and boiling sulphur.

Decompositions of Di-t-Alkyl Peroxides. III. Kinetics in Liquid Phase. JOHN H. RALEY, FREDERICK F. RUST AND WILLIAM E. VAUGHAN, *Jour. Am. Chem. Soc.* **70** (1948) pp. 1336-8.

The small variation in the first order rates of decomposition of di-*t*-butyl peroxide in cumene, *t*-butyl-benzene and tri-*n*-butylamine solution and in the vapor state is strong evidence that the same process determines the rate in all cases. This process is believed to be unimolecular scission of the peroxy-oxygen linkage. With increasing temperature the *t*-butoxy radicals become more subject to loss of methyl rather than removal of hydrogen from solvent molecules.

Manufacture: Processes and Plant

Rate of Approach to Equilibrium of Fractionating Columns. CLYDE BERG AND IVOR J. JAMES, JR., *Chem. Eng. Progress* **44** (1948) pp. 307-14.

The purpose of the study was to evolve suitable expressions through the use of which time lags of fractionating columns can be evaluated for systems having volatility ratios in the ranges normally encountered in industrial operations. The literature of the subject was first briefly reviewed. Three equations were developed that allow prediction of the time involved in reaching a given reflux composition. The first of the three is the most accurate and is applicable to those systems having volatility ratios which are nearly one. The other two are good approximations applicable when the value of a^n is high and solution of the first equation becomes cumbersome. Includes bibliography of 12 references.

Sampling Lag and Purging Time in Mixing Vessels in Series. HAROLD J. KANDINER, *Chem. Eng. Progress* **44** (1948) pp. 383-6.

An analysis is presented of the general problem of sampling lag or purging time in a series arrangement of mixing tanks of various sizes. A method for reducing complex systems, containing a random assortment of vessels of any sizes, to an equivalent simple system, containing only equal sized vessels, is developed whereby the simple system closely reproduces the purging behavior of the original complex system. To facilitate the calculation, curves are presented for systems containing up to eleven equal vessels in series. General equations are developed for systems containing either equal vessels or unequal vessels.

Vacuum Distillation of Petroleum Residues. W. W. KRAFT, *Ind. Eng. Chem.* **40** (1948) pp. 807-19.

The use of vacuum distillation in the petroleum refining industry is reviewed as well as the development of present day commercial equipment. The type of data required for design is given and a flow diagram of the typical vacuum distillation unit is included. The type of still, tower and heat transfer equipment used is described. A bibliography of 22 references is included.

A Study of Operating Variables in Thermofor Catalytic Cracking. C. BEDNARS, D. M. LUNTZ AND R. E. BLAND, *Chem. Eng. Progress* **44** (1948) pp. 293-8.

The authors present the results of a correlation study that was made to show quantitatively the effects of three most important variables involved in the operation of the thermofor catalytic cracking process, namely space velocity, reaction temperature and catalyst activity. These variables can be varied individually or together to control the depth of cracking, product distribution and quality of the products. The temperature was varied from 800° F. to 930° F., space velocity from 0.2 to 2.4, and catalyst activity from 28 to 36 A.I., when cracking a Mid-Continent heavy gas oil over activated clay catalysts.

It was concluded that maximum gasoline yields are obtained from a combination of high-catalyst activity, low temperature and low-space velocity. Increase in reaction temperature improves the ASTM and Research octane values of the catalytic motor gasoline, and has the greatest effect on the Research octane number. Gasolines made at higher temperature, however, have poorer lead susceptibility.

Within the range of operating conditions covered, and with the particular charging stock and type of catalyst used, an average increase of 4-5 percent in conversion results from a change in any one variable, as follows:

a) increasing reaction temperature by 25°;
b) increasing catalyst activity by two units;
c) halving the space velocity.

Data are presented in considerable detail in tabular and graphical form. An arbitrary definition of catalyst activity index, A. I., is given. Space velocity is defined as the volume of oil expressed as liquid volume at 60° F. charged to the reactor in 1 hour divided by the volume of catalyst in the reactive zone.

Chemical Similarity in Heterogeneous Catalysis. R. C. L. BOSWORTH, *Trans. Faraday Soc.*, **43** (1947) pp. 399-406.

In the development of processes from the pilot plant to the commercial stage it is generally considered that a limited increase in size of the equipment is necessary. The reaction is first studied in small laboratory equipment and later repeated in semi-pilot plant equipment. If successful, the process is taken to full pilot plant scale and then to commercial equipment. In general, with each change in scale there is an apparent change in optimum conditions. The author emphasizes that the organization of a small scale chemical investigation should be such as to arrange the experimental parameters in dimensionless groups. When conduction provides the principal mode of heat transfer, the length of the reaction tube and the size of the catalyst grains are directly proportional to the diameter of the reaction tube. Space velocity and catalyst activity are to be adjusted inversely proportional to the square of the diameter of the reactor. The output under conditions of

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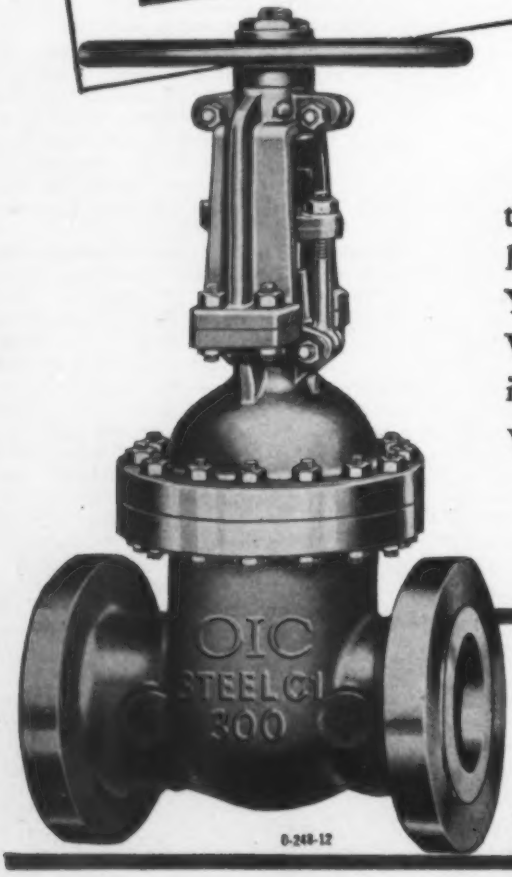

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chemical similarity, is proportional to the diameter of the reactor or proportional to the cube root of the catalyst volume.

When radiation dominates the heat transfer, similarity requires that the grain diameter and length of the reaction zone both be proportional to the two-thirds power of the diameter of the reactor, while the catalyst activity and the space velocity are both proportional to the inverse four-thirds power of the reactor diameter. The output in this case is proportional to the four-thirds power of the reactor diameter or to the square root of the volume of catalyst.

Products: Properties, Utilization and Analysis

Identification of Pennsylvania Lubricating Oils. R. E. HERSH, M. R. FENSKE, H. J. MATSON, E. F. KOCH, E. R. BOOSER, AND W. G. BRAUN, *Analytical Chem.* **20** (1948) pp. 434-44.

Studies of the lubricating oils derived from various crudes indicate that the distillation fractions from Pennsylvania oils, in general, have lower optical activity than those of the oils from other crude sources. The rotations found in the oils from 14 different refiners are tabulated. Special study was made of the oils from the Alleghany County, New York region because these showed slightly higher optical rotations than most other Pennsylvania oils. Data are given for oils from water flooding in the Alleghany County, Bradford, and Tiona fields. A study was made of the effect of five color removing absorbents on Pennsylvania 150 neutral oils, and the results are tabulated. Properties of the lubricating oil fractions from crude petroleums in various fields over the United States are given in a detailed tabulation. Pennsylvania lubricating oils show a more definite absorption band in the infrared region at 10.3 microns and, when clay-filtered in a standard manner, they show a higher rate of change in absorption with wave length in the ultraviolet region around 250 millimicrons than oils from other crude sources. Methods utilizing optical activity and ultraviolet absorption are to a large extent independent of the previous history of the oil and of the presence of the additives. A bibliography of 17 references is included.

Examination of Used Engine Lubricating Oils. K. HILFREICH, J. C. MCNICOL, AND L. ROSENFELD, *Jour. Inst. of Petroleum* **34** (1948) pp. 148-225.

The data on which the authors report was obtained in connection with a more general investigation into oil cleaning, but appear to be sufficiently interesting in themselves to be considered separately. A large number of used engine lubricating oils are discussed. Samples were supplied by operators from various parts of the United Kingdom, and numerous physical and chemical tests of them were made. The work was largely concerned with determining the amounts of contaminating matter in the samples and obtaining information on the nature of the suspended solids. considerable information was gained with regard to the significance and relative value of the different test methods. The test methods applied are described in detail and the significance of each test is discussed. Results are presented in tabular form and in a series of graphs. Influence of various operational factors on oil contamination was examined. Finally, a few methods of test are suggested for routine use in checking the quality of used crankcase oils. A bibliography of 30 references is included.

Lubricating Oil Testing in Engines. R. STANSFIELD AND J. C. CREE, *Jour. Inst. of Petroleum* **34** (1948) pp. 271-87.

Increasing use is being made of engine tests for the purpose of grading oils. However, there are recognized tests only for certain heavy duty oils, but the authors feel that it should be possible to develop other requirements as regards normal and premium grade oils. The results of a standard test in the Caterpillar single-cylinder diesel engine and in the Chevrolet engine are presented and discussed in relation to chemical laboratory inspection data. The lack of significance of the latter led to a series of Chevrolet tests in which bearing weight losses were obtained at intervals during the run and the form of corrosion curves determined. It was shown that even when the breakdown time of the oil was known it still could not be reproduced satisfactorily by tests of the unused oil in the laboratory. Use of the engine tests for determining ring sticking is discussed and preference is given to ratings in terms of quantities and nature of deposits during runs that are not continued to the point of ring stick. These for a reliable method for evaluating additives is emphasized. Precautions to be adopted to obtain satisfactory life and freedom from mechanical trouble with the Chevrolet engines are given.

Physical Studies of Gel Microstructure. C. G. SHULL, P. B. ELKIN AND L. C. ROESS, *Jour. Am. Chem. Soc.* **70** (1948) pp. 1410-4.

Physical data on the microstructure of a series of ten amorphous silica and silica-alumina gels were obtained from studies of low temperature gas adsorption, porosity and small angle X-ray scattering. Good correlations were obtained between 1) the mean pore diameter calculated from the specific micropore volume and the specific surface and the mean pore diameter calculated according to a capillary condensation theory of isotherm analysis, 2) the average particle size and the specific surface and 3) the pore to particle size ratio and the porosity factor. The authors concluded that the over-all correlations found indicate the validity of the assumptions necessary in the interpretation of the data at least for the materials that were studied.

The Determination of Pore Size Distribution from Gas Adsorption Data. C. G. SHULL, *Jour. Am. Chem. Soc.* **70** (1948) pp. 1405-10.

Considerable application has been made of gas adsorption data in determining quantitatively the physical structure of finely divided and porous materials. The theory of interpretation of gas adsorption in terms of capillary condensation is discussed by the author. It is suggested that the empirical use of experimental adsorption data for materials of large crystal size is preferable to the employment of the BET theory at the higher relative pressures in evaluating the multilayer thickness of the adsorbed layers. A simplified procedure for applying the theory of capillary condensation to experimental data, thereby obtaining the pore size distribution, is presented. Examples of this procedure are given in the treatment of data secured in the study of two silica gels.

Simple Chemical Analysis of isoButene in Binary Mixtures With Other Olefins. J. P. W. HOUTMAN, *Jour. Inst. of Petroleum* **34** (1948) pp. 255-70.

A simple method of analysis was developed for binary mixtures of isobutene with propene, butene-1, butene-2, isobutane, and butadiene, making use of aqueous hydrochloric acid at room temperature as a reagent and the usual Bunte method of gas analysis. Only isobutene reacts with formation of tertiary butyl chloride. The other gases, however, are fairly soluble in the reagent, and it is therefore necessary to apply correction. Undiluted mixtures can be analysed with an accuracy of approximately 1 percent, when the mixture contains less than 85 percent of isobutene. Above this percent it is advantageous to dilute the gas with an equal volume of indifferent gas, such as air, in which case the same accuracy can be obtained.

Determination of Aromatics and Olefins in Hydrocarbon Mixtures (Acid Solubility Test). CLYDE BERG AND F. D. PARKER, *Analytical Chem.* **20** (1948) pp. 456-7.

A modified acid solubility method offers improved accuracy in the determination of aromatics and olefins in hydrocarbon solutions. The method is simple and rapid and the errors caused by incomplete solution of olefins and only partial solution of saturates have been considerably reduced. The test is made by adding 15 percent fuming sulfuric acid to a solution of the sample in glacial acetic acid. Tests on known mixtures have determined the optimum glacial acetic acid-fuming acid ratio and have shown the method to be superior to the 98 percent sulfuric acid method. The method is particularly advantageous when applied to cracked gasolines. The 98 percent sulfuric acid test frequently presents the anomaly of a lower acid absorption than the olefin content as determined by the bromide-bromate method. The new method obviates this difficulty and the aromatic content of cracked gasolines can be ascertained by the difference between the acid solubility and the olefin content.

Determination of Asphaltenes, Oils, and Resins in Asphalt. RETHEL L. HUBBARD AND K. E. STANFIELD, *Analytical Chem.* **20** (1948) pp. 460-5.

The authors briefly discuss the limitations of previous methods for the analysis of asphalt. A method of analysis is described that largely overcomes objections to previous methods. The method permits the quantitative determination of the three groups of components, namely asphaltenes, oils

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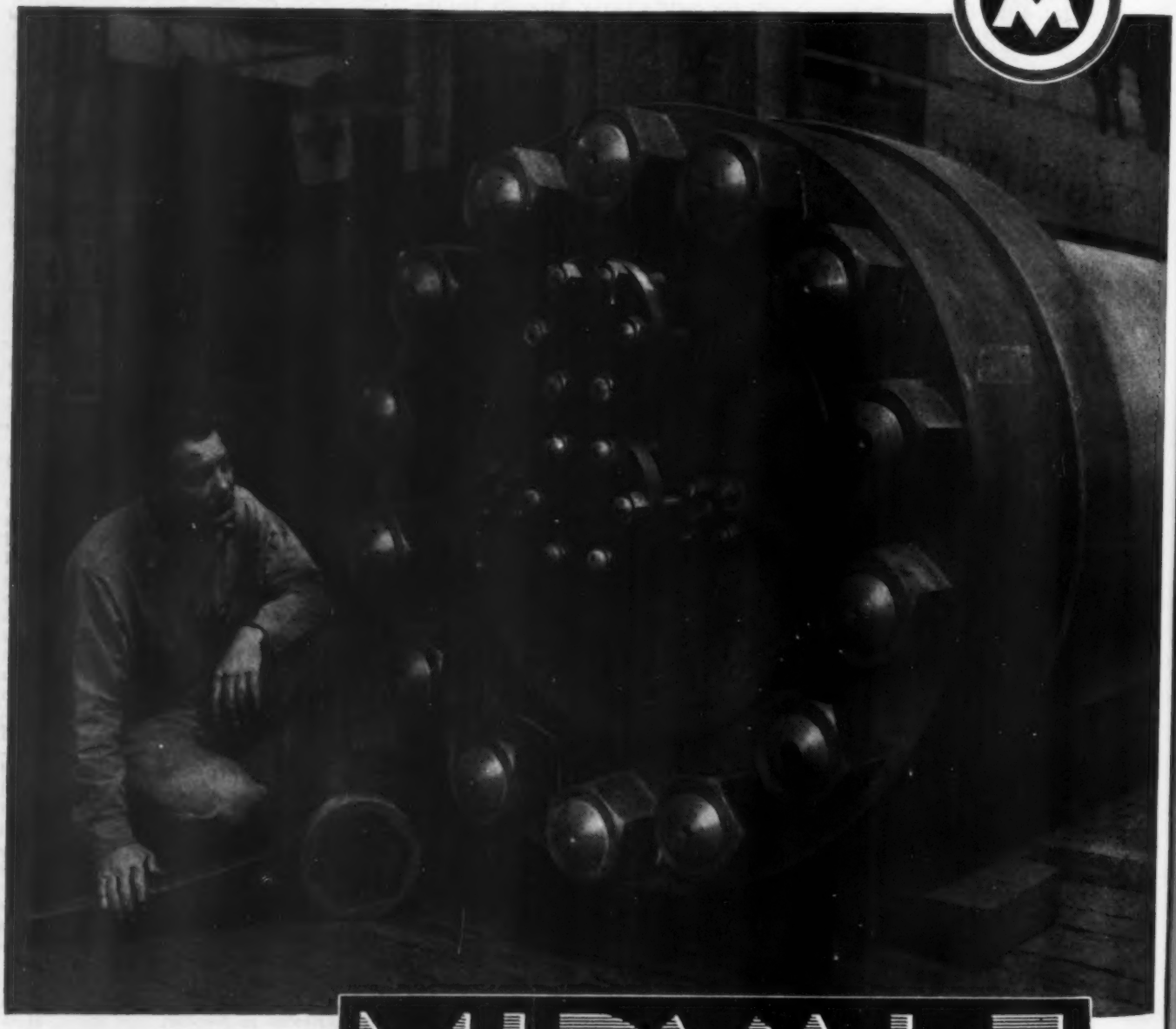

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and resins, in petroleum and native asphalts. The asphaltene (benzene-soluble, pentane-insoluble) fraction is obtained by extracting the asphalt with *n*-pentane. The pentane-soluble portion is further fractionated by adsorption on anhydrous alumina and extraction first with pentane to obtain the oil fraction and then with a methanol-benzene solution to obtain the resin fraction. In contrast to most proposed methods, the three asphalt constituents are recovered and can be used for further study. A complete analysis can be made in one 8-hour day after the sample has been dispersed in pentane and allowed to stand approximately 12 hours or overnight. Results of typical analyses are given in tabular form. The composition of a number of different crude oils are presented in chart form. A bibliography of 24 references is included.

BOOKS

The **1948 Modern Plastics Encyclopedia** has just been published and contains 1667 pages and a separate package of 12 technical charts.

The first 64 pages illustrate 122 entirely new plastics products in a wide variety of fields. Each product is accompanied with a detailed explanation of the application, the material used, how it was made and the advantages of using plastics.

The present book incorporates for the first time the Catalog of Plastics Stock Molds T which was last published in 1944. This section illustrates more than 2000 products for which stock molds are available covering molded parts, cast shapes and extrusions.

The new book, which sells for $8.50, is bound in one volume instead of three volumes. No reprints of any section will be available. Included is a complete directory of 129 pages which tells where to buy materials, machinery, supplies and services. Address Modern Plastics Encyclopedia, 122 East 42nd Street, New York 17.

The 1948 edition of **Metals Handbook** is ready for distribution by the American Society for Metals, 7301 Euclid Avenue, Cleveland 3, Ohio. The price is $15.

This edition contains 1444 pages, and is prepared by more than 600 engineering and producing specialists who are member-scientists of the society. The Handbook is divided into four principal sections: general, ferrous metals, nonferrous metals, and constitution of alloys. Articles on metals, processes and methods include new summaries of wear, oxidation, stress corrosion, relief of residual stress and service failures. Articles on ferrous metals cover the manufacture of iron and steel, through shaping, testing, structure-properties, welding, heat treating, etc.

Data sheets and articles on nonferrous metals include discussions of melting, shaping, treating, and corrosion.

Koppenhoefer Named

Dr. Robert Koppenhoefer of Socony-Vacuum Oil Company's technical service department, was made president-elect of the American Leather Chemists Association at its recent meeting in Bretton Woods, N. H.

REFINER Authors

• CONTINUED FROM PAGE 152

University of California. He joined the research and development department of Standard Oil Company of California in 1925. He began work in the dynamometer test laboratory and in 1928 took over direction of the laboratory testing of fuels and lubricants. In 1938 he went to San Francisco on an assignment on the management staff. In 1944, the California Research Corporation was formed to take over all research, development, and patent activities of the Standard Oil Company of California and its subsidiaries, and he was appointed associate director.

Among his non-professionel interests is a home workshop where has turned out a number of gadgets from wood and metal. He serves as technical director in the San Francisco area of the annual soap-box derby sponsored by Chevrolet. He is a member of several technical societies and is currently vice president of the fuels and lubricants activity of SAE. He continued his Army reserve flying until 1938.

P. L. Pinotti graduated from Stanford University in 1936 with a bachelor of science degree in biology. His first position was with T. V. A. as a biologist. Then he engaged in vegetable oil processing research as shop foreman at the engineering experiment station of the University of Tennessee, where he attended the university part time and was awarded a bachelor of science degree in chemical engineering in 1943. Shortly thereafter he joined California Research Corporation where he has been engaged in research projects in industrial and diesel lubricating oils. His new home is nearing completion in Marin County in which one of his chief interests is the workshop. Otherwise his hobbies include golf and photography.

G. R. MacPherson, born in 1909 in Los Angeles, attended the University of California where he received B.S. and M.S. degrees in mechanical engineering (1932 and 1933, respectively). He also was the recipient of the Pacific Coast Gas Association Fellowship in gas engineering at the university for two years. MacPherson joined Standard in 1934 and has been with California Research Corporation since its inception in 1944. As senior research engineer in refinery technology, he has specialized on refining problems dealing with the characteristics of crude oils and with the effect of differences in crude oil quality and product demand upon over-all refinery operations. During the war he was a scoutmaster and since then has been active in other capacities in the Berkeley-Contra Costa Area Council of the Boy Scouts of America. One of his chief interests is making motion pictures in color of children.

"Man Who Did Most" Is Still Busy at It

"SHELL and Tube Heat Exchangers," in this issue of REFINER (starts on page 139) was written by Frank L. Rubin of The Lummus Company. In the heat exchanger division since 1945, Rubin has been concerned with design problems varying from small shell and tube exchangers for chemical plants to large

FRANK L. RUBIN

catalytic reactors for refineries. He has worked at designing surface condensers, single and multiple effect evaporators and feed water heaters, steam jet ejectors, and vacuum refrigeration units in the power plant field.

Recently, he engaged in the starting up operation of a 4000-ton steam jet refrigeration unit at Baton Rouge, La., for Ethyl Corporation, considered one of the largest units of its type.

Rubin was born and reared in Brooklyn, U. S. A.; all of which started back in 1920. He attended Brooklyn College, where his participation in campus activities earned him the sobriquet "The Man Who Did the Most for the School," and his scholastic efforts brought him a bachelor of arts degree.

Rubin began attending night classes at The Cooper Union School of Engineering after graduating from Brooklyn College, and received his bachelor of chemical engineering degree in 1945. While attending engineering school at night, he worked as a draftsman on a sugar factory installation of The Honolulu Iron Works. Afterwards he spent two years in pilot plant operation and related laboratory work with the research division of The Stauffer Chemical Company. Along about this time he got acquainted with another young chemist, who later became Mrs. Rubin.

Presently, Rubin is engaged in graduate work at The Polytechnic Institute of Brooklyn. In addition to chemical engineering, he enjoys badminton, chess, golf, and tennis. And modestly enough, he admits to spending an occasional Sunday afternoon at Ebbets Field cheering for "dem bums"—the Dodgers.

He is a member of American Chemical Society, Zeredatha Lodge (N. Y. 483, F & AM), Alpha Phi Omego, junior member of American Institute of Chemical Engineers, and The Lummus Company chess club.

DIGEST of Recent United States PATENTS Pertaining to PETROLEUM REFINING

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AND COVERING PATENTS PUBLISHED IN THE OFFICIAL GAZETTE DATED APRIL 13, 20, 27 AND MAY 4, 1948

REFINING

U.S.P. 2,439,534. Extraction of Hydrocarbons. B. G. Wilkes, Jr., to Carbide and Carbon Chemicals Company.

A hydrocarbon mixture is extracted with an aliphatic cyano compound formed by reacting acrylonitrile with a mono-or polyethylene amine, or a monomethyl or monoethyl ether of ethylene glycol, diethylene glycol or triethylene glycol. Examples of the cyano compound thus formed are: N-di-(beta-cyanoethyl) amine and beta, beta'-di-(cyanoethylamino) ethane. The hydrocarbon mixture is separated by this treatment into portions enriched in more unsaturated constituents, slightly unsaturated or saturated constituents, respectively, the solvents employed possessing high selectivity for the more saturated hydrocarbons.

U.S.P. 2,439,897. Motor and Motor Fuel Treatment. J. A. Lachapelle.

Metallic lead or a lead containing alloy in the form of solid pieces is introduced in the fuel tank of an internal combustion engine where it is frictionally comminuted by contact with the wall of the tank through the engine vibration and serves as an anti-friction element and for improving the fuel combustion. The anti-knock rating of the fuel is raised.

U.S.P. 2,440,489. Process for Dehydrating Aqueous Mixtures. R. Rosen and J. C. Zimmer to Standard Oil Development Company.

For dehydrating water containing liquids which normally foam excessively on ebullition, such as hydrocarbons or lubricating oils, the evaporation of the water from the liquid by heat is effected in the presence of a small quantity, e.g., 0.001-10 percent by weight, of a liquid low-volatility polymer of a chloro-fluoro olefin monomer.

U.S.P. 2,440,493. Process for Separating Butadiene and Acetylene from a Hydrocarbon Mixture. G. H. Shipley, Jr., to Standard Oil Development Company.

A hydrocarbon mixture containing butadiene and acetylene is contacted with a first aqueous solution of ammonia cuprous acetate to absorb butadiene and acetylene from the mixture. The first rich solvent thus obtained is subjected to preliminary desorption to remove a major portion of butadiene therefrom. The resulting solvent is stripped to remove substantially all of the hydrocarbons therefrom in vaporous condition. The vaporous hydrocarbons are contacted with a second solution of ammonia cuprous acetate to absorb a major portion of acetylene and a minor portion of butadiene from the vapors. The hydrocarbons are then recovered from the second rich absorbent.

U.S.P. 2,440,617. Oil Desalting Technique. J. E. Seebold to Standard Oil Company (Indiana).

Petroleum is desalted by vigorously contacting it with a brine solution and thereafter separating the oil from this solution. The separated brine solution is recycled to the contacting step. The hydrogen ion concentration of the brine solution is controlled by adding alkali thereto after separation from the oil. The precipitate formed in the solution is separated by settling before the brine solution is recycled.

U.S.P. 2,440,673. Method of Utilizing a Fuel Gas in Refining a Petroleum Fraction. M. C. K. Jones to Standard Oil Development Company.

A petroleum fraction, such as a cracked petroleum naphtha, is treated with a fuel gas containing CO and H_2 at a temperature of 200-800° F. in the presence of a catalytic material containing a small amount of platinum or palladium incorporated in a hydrous oxide carrier with ultramicroscopic pores, such as platinized alumina containing 0.1-10 percent of platinum. City gas, coke oven gas or water gas can be used as the fuel gas. The petroleum fraction is refined by this treatment and the anti-knock value of cracked naphtha is improved by reduction of the diolefin components of the naphtha.

U.S.P. 2,440,680. Method and Apparatus for Oil Purification. F. L. Gerin to The Youngstown Miller Company.

The patent relates to the purification or re-refining of mineral oils, such as lubricating oils. The heated oil is agitated with an adsorptive material to form a slurry. Small portions of the slurry are intermittently withdrawn and filtered while the slurry is replenished with unrestored and unheated oil and adsorptive material in such amounts as to maintain the amounts of both in the slurry substantially constant. The drop in temperature caused by the introduction of unheated oil into the slurry is utilized to control the amount of slurry withdrawn at any one time.

U.S.P. 2,440,707. Refining of Naphthalene by Distillation. B. J. C. van der Hoeven to Koppers Company, Inc.

Naphthalene crude as obtained, for example, as condensate from coal-carbonization gases or the like, is fractionally distilled and a naphthalene distillate is recovered. Details of the process are claimed.

CATALYST PREPARATION, ACTIVATION, AND REGENERATION

U.S.P. 2,439,528. Azines as Olefin Polymerization Catalysts. M. J. Roedel to E. I. du Pont de Nemours & Company.

A polymerizable olefin with not more than 4 C atoms, such as ethylene, is polymerized at a pressure in excess of 4 atm. (e.g., at 200-3000 atm.) and at a temperature of 60-400° C. in the presence of 0.001-5 percent, based on the weight of the monomer, of an azine catalyst of the formula $R_2C=N-N=CR_2$ in which one R of each R_2 group is hydrogen, alkyl, alkaryl, or aryl; the other R of the same group is alkyl, alkaryl, or aryl, and the formula of the azine has a symmetrical structure. Examples of such azines are: benzalazine or diphenylketazine. No more than 1000 parts per million of oxygen shall be present during the reaction.

U.S.P. 2,439,737. Manufacture of Aluminum Bromide. V. E. Houston and A. G. Oblad to Socony-Vacuum Oil Company, Inc.

Metallic Al is contacted with Br_2 or HBr dissolved in an anhydrous saturated organic solvent for $AlBr_3$ such as liquid propane or n-butane. The bromine content of the solution employed shall be at least 5 percent by weight. The $AlBr_3$ thus formed remains dissolved in the solvent and can be employed directly in this dissolved form as a catalyst in hydrocarbon conversion reactions. The difficulty otherwise encountered in handling $AlBr_3$ because of is rapid reaction with the atmospheric moisture and of its slow rate of dissolving is thus avoided.

U.S.P. 2,439,994. Preparation of Silica-Alumina-Zirconia Catalyst. C. L. Thomas and E. C. Lee to Universal Oil Products Company.

A mixture of silica with decomposable salts of Al and Zr is heated sufficiently to convert the salts to oxides. A catalyst is obtained which is particularly useful to accelerate the conversion of hydrocarbon material and to selectively promote the formation of very high anti-knock gasoline with high yields from such material. The silica employed is preferably a hydrogel obtained by treating a solution of an alkali metal silicate with an acid.

U.S.P. 2,440,236. Catalyst. R. I. Stirton to Union Oil Company of California.

The catalyst according to this patent for dehydrogenating, reforming, aromatizating and desulfurizing hydrocarbons consists essentially of a major proportion of activated alumina or magnesia as a carrier, and a minor proportion of 1-15

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Normal Butane
Iso-Butane
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Crude Oil, Natural Gasoline and Liquefied Petroleum Products

percent of a heavy metal oxide catalytic agent distended thereon. The carrier has been stabilized by the addition of 1-15 percent of aluminum orthophosphate. Examples of metal oxides used are Cr_2O_3 and Mo_2O_3.

U.S.P. 2,439,765. Supported Acetylide J. F. Walker and T. E. Londergan to E. I. du Pont de Nemours & Company.

The metal acetylide catalyst according to this patent contains a finely divided particle form support material, such as active carbon, the size of which shall not exceed 300 mesh. An acetylide of Cu, Ag, Au, or mercurous Hg is uniformly distributed on this support material. The amount of the acetylide contained in the catalyst material shall not exceed 10 percent in the case of the Ag compound and 20 percent in the case of Cu, Au, or Hg compounds. The catalysts can be produced by bubbling acetylene through a reduced solution of a suitable salt of the metal in question in which the finely divided support material is suspended by stirring. This catalyst material is particularly useful for acetylene reactions of the Reppe type.

U.S.P. 2,440,454. Recovery of Hydrogen Fluoride in an Alkylation Process. R. E. Vinyard to Phillips Petroleum Company.

This patent claims the details of a process for the recovery of purified and concentrated HF used as a catalyst in the alkylation of an alkylatable hydrocarbon with an olefin.

U.S.P. 2,440,475. Process and Apparatus for Continuous Catalysis. V. V. Jacomini.

Hydrocarbons are introduced at elevated temperature into one end of a gravitationally descending body of hot catalyst in a reaction zone while converted vapors are withdrawn from another end of this zone. Spent catalyst is discharged and pneumatically conveyed into a regenerating zone where it is regenerated by oxygen containing gas while gravitationally descending as a body. The regenerated catalyst is gravitationally recycled to the reaction zone.

U.S.P. 2,440,498. Polymerization Catalyst. D. W. Young and H. B. Kellog to Standard Oil Development Company.

A double salt composed of a Friedel-Crafts active metal halide catalyst and a titanium alkoxy compound in which the alkoxy radical has 1-8 C atoms is dissolved in an aliphatic solvent with 1-5 C atoms, such as butane. This solution is used as a low-temperature polymerization catalyst active between O° C. and —160° C.

U.S.P. 2,440,552. Volatile Fluoride Recovery. E. C. Hughes to The Standard Oil Company of Ohio.

Gas which contains BF_3 or HF, or both, as obtained from catalytic operations, is contacted countercurrently with an absorbent, the primary absorbing component of which is dihydroxyfluoboric acid to absorb at least a part of the acidic substances present. At least part of the absorbed BF_3 and/or HF is removed from the absorbent by heating in a liberating zone.

U.S.P. 2,440,553. Recovery of Catalyst from Mixtures of Hydrocarbons therewith in the Liquid Phase. E. C. Hughes to The Standard Oil Company of Ohio.

The object of this patent is similar to that of U.S.P. 2,440,552. An oxyfluoboric acid is here employed as the absorbent to separate HF and/or BF_3 from a fluoride-hydrocarbon composition in the liquid phase.

U.S.P. 2,440,743. Promoted Acid Treated Clay Catalyst and Preparation Thereof. W. W. Gary to Filtrol Corporation.

The catalyst for the conversion of hydrocarbons, and the like, according to this patent essentially consists of acid-treated montmorillonite clay and a water soluble manganous salt, such as $MnSO_4$ or $Mn(NO_3)_2$ present in an amount from 0.05-5 percent calculated as MnO based on volatile free clay. The catalytic activity of the clay is enhanced by impregnation with the manganous salt solution.

U.S.P. 2,440,750. Polymerization Catalysts and Preparation Thereof. C. A. Kraus and J. D. Calfee to Standard Oil Development Company.

A catalyst for the polymerization of unsaturated hydrocarbons, particularly at temperatures below 0° C. is described which consists essentially of aluminum alcoholate and a Friedel-Crafts active metal halide in 1-3 molecular proportions dissolved in an alkyl halide solution in a concentration of the order of 0.7 percent. The complex salt formed from the alcoholate and the metal halide has considerably higher solubility in alkyl halide and in hydrocarbons than the metal halide itself.

U.S.P. 2,440,756. Method of Producing Catalyst. T. D. Oulton to Filtrol Corporation.

Acid activated clay cracking catalyst particles, e.g., such of montmorillonite sub-bentonite, are calcined at a temperature and for a period of time sufficient to substantially reduce the total water content (V.M.) and render the particles non-slaking but not above 1100° F. to avoid destruction of the crystal structure. The calcined particles are then impregnated in otherwise usual manner with a solution of promoter metals, such as Al, Mn, etc. Improved catalysts are obtained by this preliminary calcination of the activated clay particles or pellets.

CRACKING AND REFORMING

U.S.P. 2,439,730. Cracking Process to Produce Gaseous Olefins. J. Happel to Socony-Vacuum Oil Company, Inc.

Normally gaseous hydrocarbons, such as propane, and normally liquid hydrocarbons, such as gas oil, are simultaneously converted, to high yields of normally gaseous olefins. The normally gaseous charge is passed in direct contact with a downwardly moving stream of granular solid heat transfer material, heated before to a temperature of at least 1450° F., in the upper section of a vertical reaction zone to heat the gaseous charge to conversion temperature and cool the solid material to a temperature not lower than 1350° F. The normally liquid charge is passed in direct contact with the thus cooled solid material in a lower section of the reaction zone. The hot reaction products from both sections are cooled to prevent further reaction and fractionated together to recover normally gaseous olefins.

U.S.P. 2,440,591. Method for Preventing Erosion in Fluidized Catalytic Cracking of Hydrocarbons. W. K. Lewis to Standard Oil Development Company.

The effluent from a fluid catalyst cracking unit carrying suspended catalyst is treated by coating the catalyst particles with a liquid prior to their mechanical separation from the effluent. The coated particles are recovered and subjected to a drying action to remove the coating liquid therefrom. This treatment prevents the erosion of metal parts of the separators, e.g., cyclone separators, resulting from the impact of solid particles on these parts. A liquid boiling in the range of gas oil or lubricating oil can be employed as the coating liquid.

ISOMERIZATION

U.S.P. 2,440,751. Conversion of Hydrocarbons. H. R. Legatski to Phillips Petroleum Company.

The patent claims details of a process for isomerizing a hexane fraction which comprises 65-80 percent by weight of normal hexane and 20-35 percent by weight of methylcyclopentane, as obtained from natural gasoline and straight run gasolines. A normal hexane concentrate of 85-93 percent concentration obtained by fractional distillation of the charge fraction is isomerized at a temperature of 210-375° F. under sufficient pressure to maintain the reaction mixture in the liquid phase and in the presence of an $AlCl_3$-hydrocarbon complex. The methylcyclopentane concentrate of at least 40 percent content obtained in said fractional distillation is simultaneously isomerized at a temperature of 100-200° F. under otherwise corresponding conditions. The isohexane products thus obtained can be combined to form a motor fuel blending agent.

ALKYLATION

U.S.P. 2,439,457. Alkylation of Benzene by Long Chain Polymeric Olefins Using Sulfuric Acid Catalyst. J. J. Donleavy and M. M. Baizer to Allied Chemical & Dye Corporation.

A scission-susceptible olefin containing 8-20 C atoms is added in a period of 10 minutes to one hour to a dispersion of benzene in a H_2SO_4 condensing agent at a temperature of 5-40° C. in an amount corresponding to ½-2 mols of benzene and at least 2 mols H_2SO_4 per mol of olefin. Long chain alkyl aromatic compounds are obtained.

U.S.P. 2,439,600. Manufacture of Motor Fuel by Alkylation with a Light Cracked Naphtha. A. R. Goldsby and L. A. Clarke to The Texas Company.

A cracked naphtha charge is fractionated to separate a light liquid fraction and a heavier fraction. The light fraction which is free of aromatic constituents and contains a substantial amount of olefinic constituents but is of too narrow boiling range to constitute a balanced motor fuel is reacted with isoparaffins, such as isobutane or isopentane, in such a proportion that the molar ratio of isoparaffins to olefinic constitu-

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ents is not less than 1:1, in the presence of an active alkylating catalyst. A substantially saturated gasoline hydrocarbon fraction of broader boiling range suitable for motor fuel is recovered from the alkylation reaction products.

U.S.P. 2,439,729. Oil for Industrial Purposes and Manufacture Thereof. H. M. Guinot and A. Courtier to Les Usines de Melle (Société Anonyme).

Ethylene is introduced at atmospheric pressure into a stirred suspension of an $AlCl_3$ catalyst in a mixture of naphthalene with benzene, ethylbenzenes, benzene higher homologues, and/or ethylbenzene higher homologues at a temperature of 30-140° C. to cause ethylation of naphthalene. Use of the said benzene compounds allows the alkylation of naphthalene at atmospheric pressure.

U.S.P. 2,441,102 and 2,441,103. Alkylation Process. J. R. Meadow to Socony Vacuum Oil Company, Inc.

A paraffinic hydrocarbon with at least 3 C atoms (e.g., isobutane) is alkylated with an olefin with at least 3 C atoms (e.g., isobutylene) in the presence of HF. An excess of paraffin over olefin is maintained in the reaction zone. According to the first named patent an allyl chloride, bromide or iodide free from fluorine is added to the reaction mixture as a promoter. Tertiary butyl chloride is an example of such a promoter. High octane gasoline is obtained.

According to patent 2,441,103 HCl, HBr, or HJ is employed as the promoter.

POLYMERIZATION AND CONVERSION

U.S.P. 2,439,582. Catalytic Conversion System. F. W. Scheineman to Standard Oil Company (Indiana).

An apparatus suitable for effecting catalyst conversion of hydrocarbons with solid small particle size catalyst is claimed. The regeneration chamber is installed above the conversion chamber which is provided with a conical base. A conduit extending downwardly from this base is surrounded by outer walls which form a lower contacting chamber. An expansion joint is arranged at the juncture of the base of these outer walls with the base of the conduit inside of the lower contacting chamber, and a valve operated from the outside is provided in the conduit inside of this contacting chamber for regulating the flow of the catalyst.

U.S.P. 2,439,811. Catalytic Conversion of Hydrocarbons. J. W. Jewell to the M. W. Kellogg Company.

In the continuous conversion of hydrocarbons powdered catalyst is introduced to a conversion zone while hydrocarbon vapors are passed upwardly through this zone at a velocity sufficiently low to maintain the catalyst in a pseudo-liquid condition. Fresh catalyst is added at a specified rate. The reaction effluent is passed into a separating zone of large cross-section at right angles to the direction of the vapor flow and the catalyst particles are deflected out of the direct path of this flow. A lower dense catalyst phase and an upper phase of the vaporous reaction products mixed with a small quantity of catalyst are thus obtained. Hydrocarbons entrained are stripped out of the lower phase by an inert gas.

U.S.P. 2,439,934. Method of Producing Aromatic Hydrocarbons. P. H. Johnson and R. R. Parker to Phillips Petroleum Company.

A paraffin hydrocarbon material boiling in the gasoline range is maintained in an endothermic conversion zone at a temperature of 1000-1200° F. for a period of 0.05-1 second and in the absence of any catalyst. The resulting material containing olefins is contacted for a period of 0.5-2 seconds with a mass of solid granular catalyst which promotes exothermic aromatization and polymerization reactions. The effluent from this reaction is passed through a second endothermic conversion zone in the absence of a catalyst for 0.05-1 second whereupon the effluent of this reaction is subjected to a second exothermic reaction under conditions corresponding to those of the first step. The endothermic reactions are carried out without addition of heat from an outside source. An aromatic material boiling in the gasoline range is recovered from the effluent of the last zone.

U.S.P. 2,440,109. Method of Effecting Catalytic Reactions. F. J. Moore to The Texas Company.

In the catalytic hydrogenation of CO for the production of compounds with at least 2 C atoms, the catalyst is suspended in finely divided form in carrier liquid which is substantially non-vaporizable under the reaction conditions. A stream of this suspension is introduced to the lower portion of a vertical tubular reaction zone. CO and H_2 are dispersed in effective proportions in this stream in an amount sufficient to lift the slurry through the reaction zone by gravity displacement. The heat of reaction is removed by a surrounding cooling liquid. The effluent is treated to remove unreacted gas and products of reaction from the catalyst, which is recycled suspended in carrier liquid. The process can also be employed in the exothermic catalytic treatment of other gaseous reactants.

U.S.P. 2,440,286. Interpolymerization of Isoamylenes with Normal Butenes and Isobutene. S. H. McAllister to Shell Development Company.

Hydrocarbon fractions containing iso- and normal olefins with 4-5 C atoms are used for producing paraffins of high antiknock quality. The C_5 hydrocarbon fraction, e.g., a pentane-amylene fraction containing iso-and n-amylenes, is treated in the liquid phase with a polymerization catalyst, such as H_2SO_4 of 60-80 percent concentration, to selectively absorb isoamylenes therefrom and to form an absorption product containing 0.2-0.8 mol of absorbed iso-amylenes per mol of acid. The absorption product is contacted with a butane-butylene fraction containing iso- and n-butylene in such proportions as to form a mixture containing 0.8-1.4 mols of iso-olefin per mol of n-olefin and between 0.2:1 and 1:1 mols of iso-amylenes to iso-butylene. The mixture is maintained in intimate contact at 60-110° C. until substantial polymerization takes place.

U.S.P. 2,440,459. Synthetic Drying Oils. H. S. Bloch to Universal Oil Products Company.

An olefinic hydrocarbon fraction is reacted in the presence of a HF catalyst to form a catalyst-hydrocarbon complex. The reaction products are separated into a hydrocarbon phase and a catalyst phase comprising this complex and relatively saturated higher boiling compounds. The catalyst phase is extracted with a non-reactive solvent immiscible with and inert toward said complex and boiling below 250° C., e.g., a petroleum distillate, under conditions to remove those higher boiling compounds. A hydrocarbon drying oil is separated from the thus extracted catalyst phase.

U.S.P. 2,440,477. Synthetic Drying Oils. W. W. Johnstone to Universal Oil Products Company.

The process of this patent is similar to that of U.S.P. 2,440,459. In the present case the HF is first removed from the catalyst phase, e.g., by distillation, and the residual organic material left thereby is treated with an alkaline reagent to neutralize free acid therein. The acid-free organic material is recovered as a drying oil.

U.S.P. 2,440,482. Process and Apparatus for Contacting Fluids with Powdered Solids. H. Z. Martin to Standard Oil Development Company.

In a process for contacting powdered solids with gaseous fluids, particularly in the catalytic conversion of hydrocarbons and regeneration of catalyst particles, a reaction zone and a regeneration zone are maintained substantially at ground level and a body of dry fluidized solid particles is maintained in each zone. One zone is under higher superatmospheric pressure than the other. Fluidized particles are passed from the bottom of the higher pressure zone through a constriction to effect a drop in pressure. The withdrawn particles are then mixed with a gaseous fluid and passed to the lower pressure zone. Dry fluidized solid particles removed from the bottom of this zone are passed into a chamber into which a fluid under pressure is introduced to raise the pressure. A pressure seal is maintained between the lower pressure zone and this chamber. The solid particles removed from this chamber are mixed with a gaseous fluid and the mixture thus obtained is passed by means of the pressure in this chamber to the higher pressure zone.

U.S.P. 2,440,620. Contacting Solids and Gaseous Fluids. W. O. Taff to Standard Oil Development Company.

The claim of this patent relates to an apparatus for the treatment of a gaseous fluid with subdivided solids, such as catalyst particles, and for the subsequent stripping or purging of the contact or catalyst particles.

U.S.P. 2,440,494. Low - Temperature Polymerization of Butadiene in the Presence of Methallyl Chloride. W. J. Sparks and R. M. Thomas to Standard Oil Development Company.

Butadiene is mixed with methallyl chloride and cooled to a temperature be-

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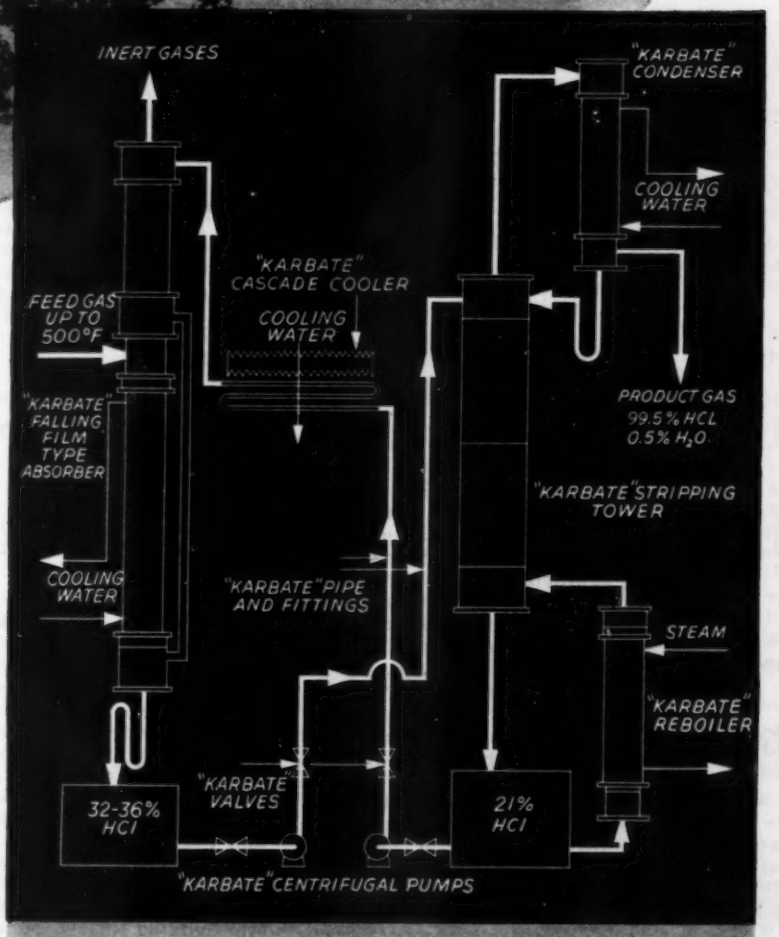

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low 0° C. A polymerization catalyst comprising $AlCl_3$ dissolved in a non-complex forming solvent with a freezing point below 0° C., such as methyl chloride, ethyl chloride, or CS_2, is contacted with the cooled mixture. The polymers obtained are soluble in naphthas, can be deposited as clear, adhering films and form with sulfur relatively hard, tough and non-brittle compounds.

U.S.P. 2,440,623. Transferring Finely Divided Solids. V. Voorhees to Standard Oil Company (Indiana).

The patent describes and claims the particulars of a method for transferring finely divided particles of solid material, such as a powdered hydrocarbon conversion catalyst, in a system between confined zones maintained under different gaseous pressures.

U.S.P. 2,440,822. Process for Conducting Catalytic Reactions. K. H. Hachmuth to Phillips Petroleum Company.

The patent relates to the catalytic conversion of hydrocarbons in a plurality of reaction zones operated in parallel in such a manner that substantially the same extent of conversion is effected in each of these zones and the extent of conversion is maintained substantially constant throughout the entire period of operation. A portion of a heated stream of the charge stock and a portion of a cooler stream of the same stock are separately introduced to each of the zones. The ratio of these two streams is individually regulated for each of the zones in such a manner that the same degree of conversion is effected in each zone while the rate of flow of the total charge to each zone is maintained substantially constant. The temperature of the total charge stock supplied to each zone is thus progressively raised as the catalyst decreases in activity.

HYDROGENATION, DEHYDROGENATION, AROMATIZATION

U.S.P. 2,440,414. Production of Cyclohexane. A. G. Oblad to Socony-Vacuum Oil Company, Inc.

A hydrocarbon stream which contains benzene and methylcyclopentane is reacted with H_2 to convert a major portion of the benzene to cyclohexane. The product stream formed is fractionated to obtain a stream consisting of an azeotrope of methylcyclopentane with benzene and a substantially benzene-free stream containing cyclohexane. The azeotrope fraction is recycled and the cyclohexane is recovered free from benzene.

U.S.P. 2,440,471. Production of Diolefins. W. R. F. Guyer to Standard Oil Development Company.

A mixture of steam with a pentene feed having a controlled proportion of trimethylethylene and of a straight-chain pentene, e.g., pentene-2, is contacted in a reaction zone with a manganese oxide, Cr_2O_3, Fe_2O_3, Co_3O_4, or Ni_2O_3 catalyst associated with MgO, ZnO, or BaO together with an alkaline metal compound with basic properties, and a stabilization oxide. The temperature in the reaction zone is maintained at 1100-1400° F. Pentadiene (from the trimethylethylene) and butadiene (from the straight-chain pentene) are obtained simultaneously in controlled proportions corresponding to the proportions of the said starting materials in the feed.

U.S.P. 2,440,492. Process for the Production of Diolefins. W. D. Seyfried and S. H. Hastings to Standard Oil Development Company.

In the production of a conjugated diolefin with 4-6 C atoms, such as butadiene, a hydrocarbon mixture including a first mono-olefin of the same number of C atoms as the desired diolefin, e.g., butylene, and a second mono-olefin with one more C atom, such as pentylene, is fed with superheated steam into a dehydrogenation zone containing a catalyst comprising 80 percent MgO, 14 percent Fe_2O_3, 3 percent K_2O and 3 percent CuO. A temperature of 1150-1300° F. is maintained in this zone. The proportion of the first and second olefins in the mixture can vary from 3:1 to 1:3. The yield of the desired diolefin is substantially greater than that obtainable under comparable conditions from the first mono-olefin alone.

U.S.P. 2,440,525. Dehydrogenation of Hydrocarbons. B. E. Roetheli to Standard Oil Development Company.

Hydrocarbon vapor is discharged horizontally into a down-flowing fluidized mass of solid catalyst particles. The fluidized mass has an annular form. The horizontal velocity is adjusted in a particular manner to limit the contact time. The vapor reaction products withdrawn upwardly from the fluidized mass are immediately quenched by an upwardly flowing gaseous cooling medium. The spent catalyst particles are regenerated and returned to the reaction zone while still hot.

U.S.P. 2,440,869. Catalytic Destructive Hydrogenation. C. W. Montgomery, J. B. McKinley, and V. J. Anhorn to Gulf Research & Development Company.

Petroleum residues are subjected together with hydrogen and a catalyst to a temperature of 800-950° F. at increased pressure. The catalyst used comprises a hydrated synthetic magnesium silicate-calcium silicate compound impregnated with molybdenum oxide. The petroleum residues are destructively hydrogenated by this treatment and gasolines, gas oil and the like are obtained.

U.S.P. 2,441,095. Conversion of Alkyl Aromatic Hydrocarbons into Alkenyl Aromatic Hydrocarbons. H. A. Cheney and S. H. McAllister to Shell Development Company.

Olefin substituted aromatic hydrocarbons, such as styrene, are produced by subjecting alkyl aromatics having at least one substituent alkyl group of at least three C atoms, e.g., isopropylbenzene, to destructive dehydrogenation at a temperature of 350-750° C. in the presence of a suitable catalyst in a first conversion zone. Olefin-substituted aromatics of the same number of C atoms as the charge together with such olefin-substituted compounds of a lesser number of C atoms than the charge and hydrogen are obtained by this treatment. The olefin-substituted compounds with a lesser number of C atoms are separated from the effluent and the remainder of the latter is subjected to hydrogenation conditions to convert the olefin-substituted aromatics contained therein to alkyl aromatics. At least part of the effluent of this second treatment is passed to the first conversion zone.

DESULFURIZATION

U.S.P. 2,439,777. Separation of Thiophenes from Hydrocarbons by Azeotropic Distillation. G. R. Lake and J. M. Stribley to Union Oil Company of California.

A complex hydrocarbon fraction containing paraffins, naphthenes, olefins, aromatics and thiophene and/or its homologues is azeotropically distilled in the presence of a sufficient amount of an azeotrope former. The distillation is continued at a temperature sufficiently high to vaporize the azeotropes of all the hydrocarbons with said azeotrope former until all hydrocarbons together with this azeotrope former are completely vaporized. The sulfur compounds remain in the residue. The azeotrope former employed shall boil below, but not more than 35° C. below the sulfur compounds and shall be a heterocyclic compound which contains at least one oxygen or nitrogen atom in the ring, or a nitrile.

U.S.P. 2,440,258. Refining of Petroleum Distillates. L. P. Elliott and M. M. Holm to California Research Corporation.

A sulfur and aromatics containing petroleum distillate is extracted with liquid SO_2. The extract obtained contains a major fraction of the aromatic hydrocarbons of the distillate. The raffinate obtained is theerafter extracted with conc. HF. The second extract consists essentially of sulfur compounds and is free of aromatics.

HEAVY OILS AND WAXES

U.S.P. 2,439,434. Method and Apparatus for Dewaxing Oils. H. O. Lindgren to Aktiebolaget Separator - Nobel, Stockholm.

Wax-bearing mineral oils, tars and distillation or transformation products thereof are chilled in countercurrent heat exchange relation to a flowing heat absorbing liquid to separate wax and substantially wax-free oil. The separated dewaxed oil is utilized as the heat absorbing liquid. A predetermined temperature differential is maintained throughout the heat exchange system between the heat-absorbing dewaxed oil and the wax-bearing oil by chilling the dewaxed oil in the course of its flow in heat exchange relation with the wax-bearing oil. The expense of chilling the wax-bearing oil is reduced by use of the cold dewaxed oil as the heat absorbing liquid.

U.S.P. 2,439,610. Stabilized Organic Composition. R. C. Morris, J. L. Van Winkle, and A. V. Snider to Shell Development Company.

The lubricating composition formed according to this patent comprises a mineral oil and a small sulfurized homopolymer of an alkyl substituted 1,3-pen-

tadiene or a copolymer of such a monomer with hydrocarbons possessing at least 2 sets of unsaturated linkages in the molecule, the alkyl substituent having up to 2 C atoms. The additive has an antioxidant effect.

U.S.P. 2,439,734. Lubricating Oil Additives. C. M. Himel and G. C. Bailey to Phillips Petroleum Company.

The lubricant according to this patent comprises a major proportion of a lubricating oil and 0.01-5 percent by weight of the oil, of an unsubstituted alkyl sulfenamide, such at N-t-butylsulfenylmorpholine, N-t-sulfenylpiperidine, or N-phenyl-N-methyl-t-butyl sulfenamide. The additive is an oxidation inhibitor.

U.S.P. 2,439,819. High Efficiency Lubricants. J. M. Musselman to The Standard Oil Company (Ohio).

The patent relates to a lubricant which comprises a lubricating oil, a compound of Cr or a metal below Fe in the emf series, and the reaction product of P_2S_5 with an oxygen-containing wax reacted at a temperature sufficiently high to separate a phosphorous and oxygen-containing residue. The additive improves the stability of the oil.

U.S.P. 2,439,820. Compound Lubricants. J. M. Musselman to The Standard Oil Company of Ohio.

The product claimed in this patent is similar to that of U.S.P. 2,439,819. In addition to the heavy metal compounds and the P_2S_5 reaction product named there, a compound of Ba or metals with not more than 4 electron orbits from groups I-III of the periodic system is used here as the additive.

U.S.P. 2,439,821. Lubricant Preparation. J. M. Musselman to The Standard Oil Company (Ohio).

The product claimed here is also similar to those of U.S.P. 2,439,819-20. In the present case the additive consists of a Ba-containing compound of the reaction product of a phosphorus sulfide and an ester wax reacted at a temperature at which most of the phosphorus separates from the reaction product.

U.S.P. 2,440,375. Lubricating Oil. R. F. McCleary to The Texas Company.

According to this patent there is incorporated into mineral lubricating oil a small proportion of an oil-soluble metal salt of a compound which is the reaction product of a methylol-forming aromatic compound with equimolecular quantities of formaldehyde and a secondary amine. The oil composition obtained possesses detergent, anti-oxidant and anti-corrosive properties and is of improved stability in service and storage.

U.S.P. 2,441,023. Lubricating Oil Compositions Containing Polymerized Allyl Esters of Carboxylic Acids. R. G. Larsen and K. E. Marple to Shell Development Company.

A hydrocarbon lubricating oil is compounded with a minor amount of a polymer of an ester of a allyl alcohol having 3-18 C atoms with a saturated monocarboxylic acid having 8-13 C atoms. The ester has a double bond of aliphatic character between two C atoms one of which is attached directly to a saturated C atom which in turn is attached di-

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rectly to the O atom of the carboxyl group of the ester. The polymer shall have a degree of polymerization of 4.3-12.1 and is obtained by heating the ester in the presence of a peroxide or oxygen catalyst at 50-300° C. Allyl laureate is an example of the ester to be employed. The viscosity index of the lubricant is appreciably increased by the additive.

U.S.P. 2,440,530. Stabilized Organic Compositions. W. J. Yates to Shell Development Company.

The composition according to this patent comprises a major proportion of a refined mineral oil, an amount of 0.0025 percent of a saturated alkyl succinic acid of at least 16 C atoms, and an amount of 0.01 percent of an N-alkylated diamino diphenylmethane. The additives inhibit decomposition by oxidation of the mineral oil in the presence of a metal surface.

U.S.P. 2,440,991. Oil Compound. S. J. Wayo to Sinclair Refining Company.

A lubricating oil fraction is compounded with a minor proportion of an alpha, alpha'-thiocarbono-dialiphatic acid of the formula: $C{:}X(S{\cdot}CH(COOH)(CH_2)_m\,CH_3)_2$ wherein X is S or O and m is one of the integers 13 and 15. The oil composition is especially adapted to use as a turbine oil. The additive retards rusting.

PETROCHEMICALS

U.S.P. 2,439,513. Adipic Acid Process. C. H. Hamblet and A. McAlevy to E. I. du Pont de Nemours & Company.

Cyclohexane is oxidized with air at a temperature of 50-175° C. and under a pressure of 50-500 psi. until 0.5-2 moles of oxygen react per mole of cyclohexane attacked. The non-oxidized cyclohexane is separated from the reaction mixture. The cyclohexane-free reaction mixture is then oxidized with HNO_3 at a temperature of 50-150° C. and at a pressure of 15-500 psi. to adipic acid. The overall yield of dibasic acid is improved by carrying out the oxidation of the cycloparaffin in a series of steps.

U.S.P. 2,439,812. Method of Making Phenol. R. H. Krieble and W. I. Denton to Socony-Vacuum Oil Company, Inc.

A mixture of benzene and oxygen-containing gas is continuously passed under a pressure in excess of 500 psi. through a reaction zone at a temperature of 600-950° F. The reaction zone has a metallic surface and is void of solid catalyst. An olefin-containing hydrocarbon with a so-called "potential hydrogen donor ability" value greater than about 2.5 is incorporated in the reaction mixture in an amount such that the olefin concentration of the reaction mixture is within the range of 0.25-5 percent by volume. Phenol is obtained. The conversion of benzene to and the yield of phenol is substantially improved by the additive, e.g., by a minor amount of a cracked gasoline containing olefin.

U.S.P. 2,440,233. Oxidation of Benzene to Phenol with an Organic Promoter. R. H. Krieble and W. I. Denton to Socony-Vacuum Oil Company, Inc.

A mixture of benzene vapor and oxy-

2 NEW WILLSON* MONO Goggles

Some like 'em CURVED

Some like 'em FLAT

Newly styled plastic eye protection with choice of curved or flat lenses offer new features designed to add to their already predominant popularity. The WILLSON MONOGOGGLE, just over an ounce in weight, is the answer to getting safety equipment worn on many hazardous jobs.

- The new flat lens design retains all the safety features of the curved lens.
- Both provide ample room for wearing of prescription glasses in comfort. The flat style, however, provides additional clearance for molded spectacle frames.
- New drop-eye shape gives wider vision.
- Greater ventilation area provides better air circulation and more wearer comfort.
- Both new designs available in clear acetate frames or the new flexible, mottled-brown, polythene frame.

WILLSON*

For complete information on these products and their application, as well as other eye and respiratory protective devices, get in touch with your Willson distributor or write us direct.

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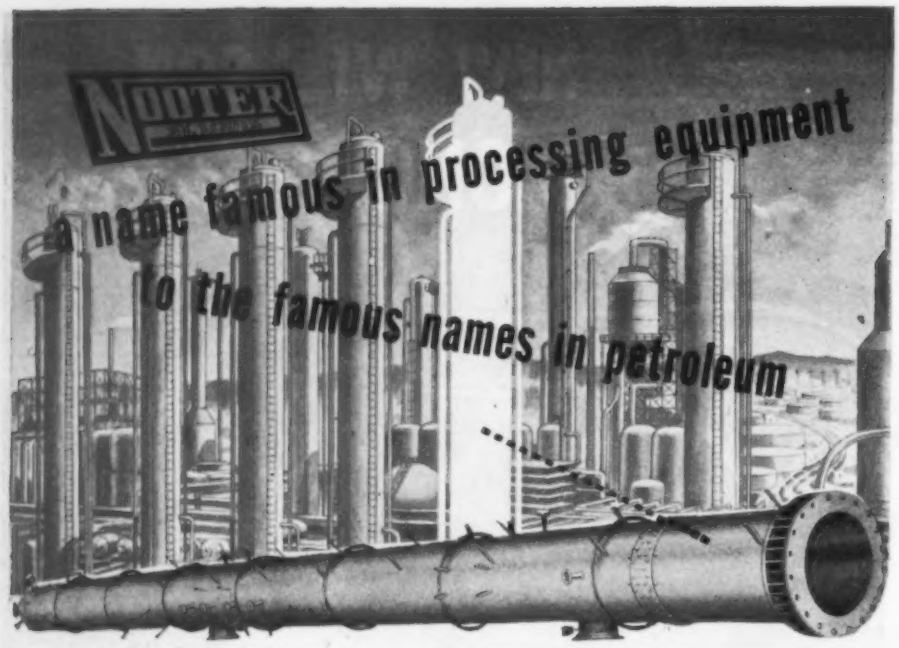

Fractionating Tower of Silicon Bronze, 3' 6" ID, 80' high, ¼" to ⅞" varying thicknesses, with X-Ray tested welds — entirely fabricated by Nooter.

To the large and the small—Nooter is a name that has always been associated with long, dependable service.

One of the world's finest and most completely equipped plants, Nooter offers every advanced technique and modern facility to assure more dependable, safer fabrication. Nooter Dura-Pure Welds meet all API and ASME Code specifications—and the latest testing, stress relieving, and X-Ray equipment are at your service to guarantee flawless construction.

More than half a century of experienced craftsmanship backs the Nooter guarantee of superior fabrications. Experienced metallurgical specialists who know the properties and behavior of metals and alloys protect the quality of your fabrication through every phase of production.

Depend on Nooter—whenever you need refining and processing equipment fabricated to your specifications.

Agitator Tanks • Condensers • Coolers • Distillation Equipment • Ducts • Evaporators • Extractors Fractionating Equipment • Heat Exchangers • Pressure Vessels • Separators • Jacketed Vessels • Vacuum Tanks • Treating Tanks.

NOOTER ST. LOUIS

Send for bulletin on the advantages of Nooter fabrications.

JOHN NOOTER Boiler Works Co. • 1404 S. Second St., St. Louis 4, Mo.

gen-containing gas is passed under a pressure in excess of 500 psi. through a reaction zone at a temperature of 650-1000° F. A proportion of 0.2-3.0 percent by volume, based on the quantity of benzene, of a C and H_2 or a C, H_2 and O compound in the gaseous phase is incorporated in the reaction mixture, this compound having a "potential hydrogen donor ability" value greater than about 2.5. Examples of this additive are cyclohexane, cyclohexene and hydrogenated benzene generally. The reaction zone has a metallic surface and is void of solid catalyst. Phenol is continuously obtained in good yield.

U.S.P. 2,440,234. Process for Oxidation of Benzene to Phenol Promoted by Added Ethers. R. H. Krieble and W. I. Denton to Socony-Vacuum Oil Company, Inc.

The process according to this patent is similar to that of U.S.P. 2,440,233. In the present case diethyl ether, beta', beta'-dichloro diethyl ether, or dioxane is employed as the promoter. The temperature limits are 600-950° F. and no definite lower pressure limit is given. Phenol is obtained in continuous operation.

U.S.P. 2,440,800. Halogenated Hydrocarbons and Method for Their Preparation. W. E. Hanford and R. M. Joice, Jr., to E. I. du Pont de Nemours & Co.

A reaction mass comprising a polymerizable monoolefin aliphatic hydrocarbon, such as ethylene, and CCl_4 is subjected to a pressure of 20-1000 atm. and a temperature of 60-150° C. in the presence of a peroxygen compound, such as benzoyl peroxide, as catalyst. Compounds are obtained which contain in their molecule a plurality of molecules of the olefin employed for each molecule of CCl_4 and have in the case of the use of ethylene as the olefin the formula: $Cl — (CH_2 — CH_2)_n — CCl_3$. Instead of CCl_4 other halogenated methanes or alkanes can be employed.

U.S.P. 2,440,801. Process for Reacting Hydrogen Chloride with Olefinic Compounds, and Product. W. E. Hanford and J. Harmon to E. I. du Pont de Nemours & Company.

A mixture comprising a polymerizable vinyl compound, such as styrene, water, HCl, and a peroxygen catalyst is heated at 50—250° C. The ratio of HCl to vinyl compound and of HCl to water shall be, in each instance, at least 1 to 20. Liquid to solid products are obtained which contain a plurality of bivalent units corresponding to the vinyl compound employed while the two terminal valences of the chain are satisfied by H- and Cl-radicals respectively.

U.S.P. 2,440,997. Process for Producing Trans-1,2-Dichlorethylene. E. Adler to Stockholms Superfosfot Fabrics Aktiebolag.

Acetylene is passed through a HCl solution of $CuCl_2$ in the presence of $HgCl_2$. Trans-1,2-dichlorethylene is obtained. The acetylene passed through said solution can be mixed with chlorine. The $CuCl_2$ is transformed in the reaction to Cu_2Cl_2 while the $HgCl_2$ functions as a catalyzer.

Valve on outdoor steam line 20' above ground is covered with 85% Magnesia. Note that valve body is very close to building wall. How would you protect the insulation on this valve from the weather?

A. Cover with light gauge galvanized metal accurately shaped to fit valve

B. Trowel on two one-eighth inch thick coats of weatherproof plastic

C. Wire roofing paper between valve and wall—cover the rest with plastic

HERE'S WHAT THE ARMSTRONG ENGINEER RECOMMENDED:

The best method of weatherproofing outdoor valves depends upon the location of the line and the service conditions involved. For outdoor lines that are exposed to bumping or abrasion, the additional protection of metal jackets is often worth the extra expense.

In the majority of cases, however, two coats of Armstrong's Insulmastic trowelled on over the asbestos cement finish will provide excellent protection against the weather. Insulmastic will not crack in cold or soften in heat. It is fire resistant, flexible, and smooth.

On the valve described above, there was not enough room between the insulation and the wall to make a perfect job of trowelled-on Insulmastic. The Armstrong engineer recommended that the insulation next to the wall be protected with roofing paper wired on. The more accessible parts were then weather-proofed with two coats of Armstrong's Insulmastic.

"Take nothing for granted" is an unwritten law with Armstrong engineers in estimating heat insulation jobs. Small details like the location of a valve in relation to a wall get careful scrutiny. If left to "mechanic's option," you'll find these details are done with equally conscientious skill by Armstrong's installation workmen.

On your next heat insulation job, call the nearest Armstrong district office for an estimate.

FREE INSULATION CHART

This chart lists types and thicknesses of insulation for temperatures from 300° below zero to 2800° F. Write for your copy to Armstrong Cork Co., Industrial Insulation Department, 7507 Maple Ave., Lancaster, Pennsylvania.

ARMSTRONG'S INDUSTRIAL INSULATION

Complete Contract Service For All Temperatures

From 300° Below Zero

To 2800° Fahrenheit

SAVE 3 Ways

with B-H No. 1 Cement
for insulating valves and other irregular surfaces

Here's the insulating cement that makes it practical to stop heat loss—even on areas that must be occasionally serviced. B-H No. 1 Cement is efficient, easy to use and resists temperatures up to 1800° F.

Faster to use. With B-H No. 1, you simply add water, mix and apply. *It sticks instantly!* It won't slide off bottom surfaces or roll up behind the trowel. Special rust inhibitor prevents pitting and corrosion.

Better coverage. B-H No. 1 is economical to use—with a wet coverage up to 60 square feet, 1-inch thick per 100 pounds! It dries without cracking or peeling. And it's reclaimable up to 1200° F.

Bigger heat savings. B-H No. 1 stops heat loss, even at high temperatures—because it's compounded of *black* Rockwool. For example, a 3-inch application reduces 800° F to 150° F.

There are hundreds of places where you can turn heat losses into profits with B-H No. 1 Cement. Send the coupon for descriptive literature and a working sample.

SEND FOR SAMPLE

BALDWIN-HILL COMPANY
784 Breunig Avenue, Trenton 2, N. J.
Send free sample of B-H No. 1 Cement and 24-page data book "Industrial Relations."

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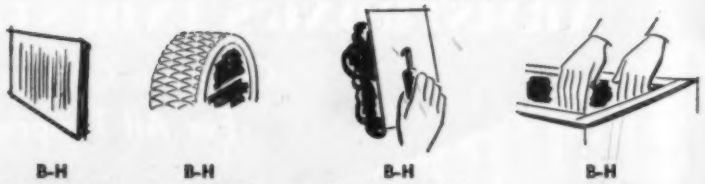


B-H MONO-BLOCK | B-H BLANKETS | B-H WEATHERSEAL | B-H FELTS

New EQUIPMENT MANUFACTURERS' LITERATURE

FOR COPIES OF MANUFACTURERS' LITERATURE OR MORE INFORMATION ON PRODUCTS DESCRIBED ON THESE PAGES USE THE NUMBER SHOWN FOR EACH ITEM AND THE ADDRESS LISTED

1—Manometer

"Simplicity and high precision in making either absolute or differential measurements of pressure and vacuum" are obtainable through a new type manometer developed by Emile Greiner Company, 161 Sixth Avenue, New York. This new instrument reduces the task of cleaning and filling a closed-end manometer to the same relatively simple process of cleaning and filling an open end U-tube type. Only a single reading is required to obtain a precise measurement automatically corrected for ambient temperature and reduced to a height of mercury at 0° C. The glass part and scale of this manometer are mounted on a functionally designed aluminum stand having a rigid three point support. The vinylite scales also have high dimensional stability and are designed to preserve the markings with a laminated cover of transparent vinylite over a milk white base upon which the markings are clearly printed in black.

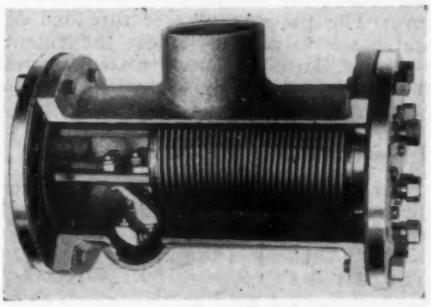
2—Piston Ring

Wilkening Manufacturing Company of Philadelphia and Toronto, has announced its new Pedrick chrome-faced piston ring with "an efficient life that is two to four times longer than other rings." Long wear results from the high anti-friction and lubricant-retaining characteristics of the chrome face, in both heavy-duty, high-temperature service and where abrasive dust is present. It is claimed also that the chrome plating reduces cylinder wear and the wear of all the other rings in the installation.

3—Aneroid Manometer

For measuring and controlling flow, liquid level or specific gravity of those applications which involve caustics or difficult acids such as sulphuric, acetic, nitric, phosphoric, a new measuring device has been added to the regular line of Aneroid Manometers made by Taylor Instrument Companies, Box 110, Rochester 1, N. Y.

The housing and all internal parts coming in contact with corrosive mediums are made of Type 316 stainless steel. Thus no sealing fluids or purges are necessary. The balancing agent is a torque tube to eliminate any need for liquid. The elimination of mercury prevents product contamination from this source and results in process economy. Available in ranges of 20, 50, 100 and 200 inches of water differential with a body pressure rating of 300 psi.



Aneroid Manometer

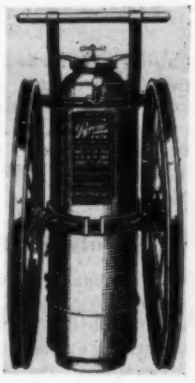
4—Plastic Pipe

A new corrosion-proof plastic pipe has been developed by United States Rubber Company, Rockefeller Center, New York. It is made of the company's new Kralite, a blend of synthetic rubber and thermoplastic resins and will be supplied in rigid and semi-rigid forms in sizes ranging from ¼ to 2 inches o.d. It may be bent to various radii and threaded for fittings.

The pipe is more expensive than most types of metal pipe, but is "better resistance to chemical corrosion and weather."

5—Extinguisher

A new, wheeled, foam engine, designed "to produce better fire-fighting foam and more of it faster," has been announced by Pyrene Manufacturing Company, Newark, N. J. The extinguisher, of 40-gallon capacity, will deliver from 375 to 400 gallons of foam in 3½ minutes. The interior has been redesigned to alter the rate of chemical action and an improved foam stabilizer has been introduced into the chemical charge, it was explained. Equipped with 50-inch steel wheels and 50 feet of 1¼-inch chemical hose, the engine comes in three models—indoor, outdoor and airport. The new unit is labeled "Pyrene Foam Fire Extinguisher." In foreign markets, the former name "Phomene" will be used.



6—Steam Heated Plug Valve

The "Hot-Spot," new model Hamer plug valve, announced by Hamer Oil Tool Co., 2919 Gardenia Ave., Long Beach 6, Calif., is designed to use on lines carrying asphalt, tar, and other services where heated valves are required. Heat is applied from a chamber on the lower part of the valve to which steam lines are attached. Heat is transferred through the body and the plug. The "Hot-Spot" valve also has the plug adjusting nut feature incorporated in all Hamer valves, a feature which assures that the valve may be opened or closed under all conditions and will not stick. The plug adjusting nut when turned to the right lowers the plug into its seat and holds it in correct adjustment for routine operation. "Hot-Spot" valves are available in sizes 2, 2½, 3, and 4 inches. Larger sizes soon will be available.

7—Tank Paint

Sheffeld Bronze Paint Corporation, 17814 Waterloo Rd., Cleveland 19, Ohio, has developed a "revolutionary" new aluminum tank paint, "proven by weather-o-meter tests showing that at the equivalent of 1½ years of extreme exposure, the tank paint showed absolutely no signs of deterioration." This paint, formulated with a special long oil synthetic resin vehicle and a fine aluminum paste, "will cover all primed surfaces in one coat, will not bleed through red primer and will not turn a dull gray." Tests show that the paint develops a maximum hardness in about two days after application, at which time it becomes insoluble in most common solvents.

8—Power-Driven Staging

A new lightweight power-driven staging unit, said to make ordinary rigging methods for "high work" jobs obsolete, has been developed by Spider Staging Company, 8th Avenue North, Renfon, Wash. The new unit, called "Spider Staging," for use in many types of off-the-ground work, including painting, sandblasting, steam cleaning, general maintenance operations, etc., is constructed of aluminum alloy, with a double guard rail completely surround-

ing the operator. The stage is suspended on an extra flexible wire rope which winds on a power-driven drum beneath the platform of the unit. Power unit consists of a totally enclosed 172-to-1 reduction gear driven by a standard ⅓ hp capacitor type electric motor. Operator controls the stage by means of a standard Cutler-Hammer three-button reversing switch and can ascend or descend vertical drops of up to 650 feet, at an average speed of 18 feet per minute. Two Spider Stagings can be joined with a connecting platform to make a power-driven swing stage. Safety features include three independent automatic braking systems, any one of which will prevent the stage from falling. In addition, there is an automatic overload switch which cuts off the power in the event of an overload.

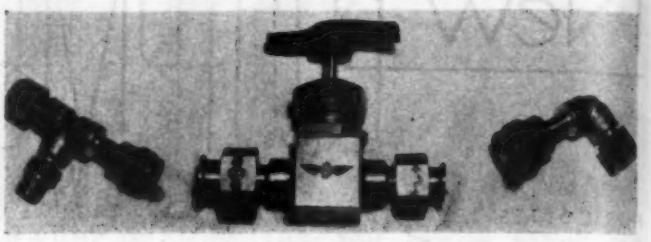
9—Magnetic Gas Valve

General Controls Company's (801 Allen Avenue, Glendale 1, Calif.), K-3H (hermetically-sealed) magnetic gas valve "combines advanced design and operational features to eliminate the possibility of gummy or foreign matter forming in the solenoid and restricting plunger operation." A diaphragm construction positively seals the operator from the fuel gas without interfering with valve operation. The solenoid operator is completely sealed to atmosphere and in event of diaphragm rupture prevents all external gas leakage. The K-3H closes automatically upon current failure.

The K-3H valve opens and closes a gas fuel supply line in response to limit controls or similar devices. This valve is available in sizes from ⅜ to 1¼-inch I.P.S., inclusive.

10—Shut-Off Valve

An entirely new design shut-off valve, announced by Greer Hydraulics, Inc., 454 18th Street, Brooklyn, features induction brazed joints which are capable of withstanding pressures up to 20,000 psi without leakage. The valve was designed for use in systems operating pressures up to 5000 psi. The valve works on a unique feature: The poppet valve is threaded to match the valve stem whose movement is rotary. Turning the valve stem moves the poppet toward its seat which makes a perfect seal when contact is made. Both the seat and the poppet are readily replaceable. This valve is easily installed in any circuit and also easy to disassemble when necessary. The unions are flush-mated.

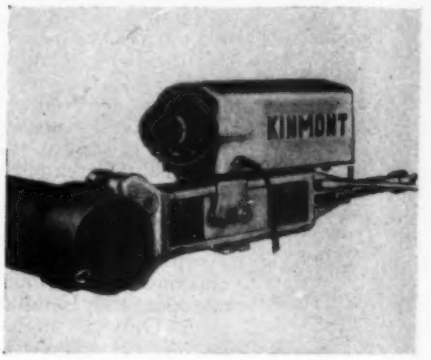


11—Portable Air Compressors

Two portable fractional-horsepower air compressors have been announced by American Brake Shoe Company's Kellogg Division, 230 Park Avenue, New York 17. Both models produce 100 percent oil-free air with special design eliminating all contact or contamination of the air with lubricating oil. Both compressors are readily adjustable for different pressures. Model 17-C (with handle) delivers 4.4 cfm free air at 40 pounds pressure. Model 8-C delivers 2.2 cfm at 25 pounds pressure. It is powered with a ¼-H.P. electric motor. Both compressors are said to be particularly adaptable for low-pressure, high-volume work.

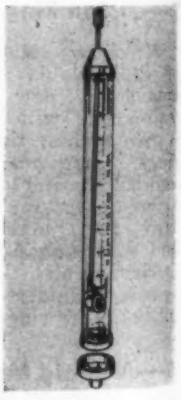
12—Universal Power Unit

A universal power unit "for the turning of any round, nearly round or hexagonal object requiring up to 400 pounds circumferential turning force at a surface speed of from 3 to 26 inches per minute" has been announced by Kinmont Manufacturing Company, Inc., 718 West Wilson Avenue, Glendale 3, Calif. It is especially adaptable as a positioner for welding, cutting, fitting, grinding, threading, painting, sandblasting and other similar operations. With adapters of various types the uses to which this machine can be applied are numerous. The unit operates on the chain tong principle, and weighs only 71 pounds. A foot switch accessory is available to permit remote control. The drive chain is provided with patented quick action connecting links for rapid lengthening of the chain to accommodate work of larger diameter.



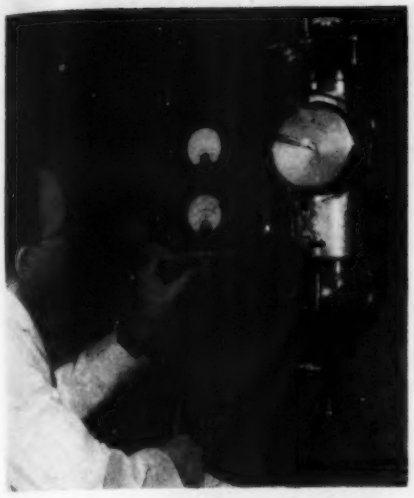
13—"Oil Thief"

The A. J. Manufacturing and Distributing Company, 5228 Bonita Ave., St. Louis 9, has announced a new oil thief for sampling oil for water in tanks and tankcars. The "Snooper" thief "is designed for simplicity and accuracy." The releasing mechanism is so constructed that none of the strata of liquids in tank will be greatly disturbed during sampling. Sample taken, therefore, corresponds to the actual strata of liquids being tested. The transparent calibrated test is unbreakable and shows at a glance how much dilution is present in the tank sampled. A small die cast funnel for transferring contents from the "Snooper" to sample bottles comes with each unit.



14—Centrifugal Molecular Still

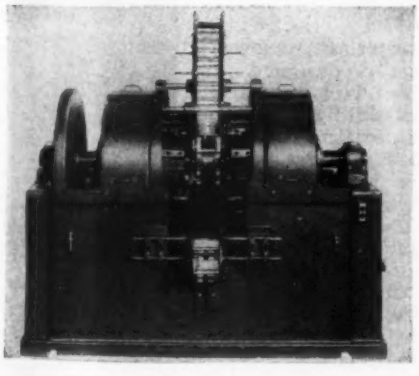
A unit for distilling fats, oils and waxes by molecular distillation at the laboratory bench is announced by Distillation Products, Inc., 755 Ridge Road West, Rochester 13, N. Y. Simple, com-



pact, portable and inexpensive the new model, Type CMS-5 employs a centrifugal evaporator embodying the same principals as DPI's large commercial stills, so that the results obtained in the laboratory can be translated into terms of commercial production.

The CMS-5 has the unique distinction of operating with little danger to the substance under distillation—hundreds of thousands of times less than the hazard of ordinary laboratory vacuum stills. The still, 32 inches high, occupies about three square feet of bench space, exclusive of the mechanical pump which also covers an equal area. Meters and controls are mounted on a single panel and include a thermocouple dial, Pirani type vacuum gauge and a variac to control the temperature of the evaporator.

15—High-Speed Flanger



The first fully automatic high-speed flanger for square or rectangular cans, introduced by Lima-Hamilton Corporation, 60 East 42nd Street, New York 17, die-flanges both ends of the can simultaneously producing an even right-angle flange on corners and sides of the can without distorting the can body. The flanger consists of five flanging stations, is completely self-contained with individual motor drive. Rigidity of the heavy shaft, mounted in roller bearings, prevents any deflection of flanging heads when taking full flanging load. The unit can handle a maximum of 150 cans a minute.

16—Temperature Control

The Gyco-Phen Electronic Temperature Control, a new instrument which regulates power flow into electrically heated devices according to temperature variations, is announced by Scientific Glass Apparatus Company, Inc., of Bloomfield, N. J. It may be used to reach and maintain any desired temperature within the range of 0-500° C. and its rated sensitivity is plus or minus 0.25° C. It is fully portable. No charts or calibrations are needed to operate it. The dial for temperature control reads directly in degrees centrigrade. The inner dial is calibrated in single degrees from 0 to 100 while the outer dial covers 100 degrees for each graduation. A zero-set knob allows adjustment of the set to any reference temperature.

Requests for manufacturers' literature get prompt replies when you identify each item by number and name listed in Petroleum Refiner.

17—Motor Starter

For protecting high voltage motor circuits against damage from short circuits, The Electric Controller & Manufacturing Company, 2700 East 79th Street, Cleveland 4, Ohio, has announced a new line of starters for use with 2300-4600 volt motors. Known as "Valimitor" (volt - ampere - limitor) motor starters, they are designed for use, with safety, at any point on any power system, regardless of the available KVA. These starters limit the maximum fault current that can be obtained on any system to approximately 25,000 KVA, which is easily interrupted by the Type ZHS magnetic contactor used in these starters. The interrupting capacity rating of the ZHS is actually 50,000 KVA, and under a maximum fault condition, the electromagnet forces set up in the starter will be only one fourth of this

J-M SEA RINGS LAST LONGER...

BECAUSE FLUID PRESSURE
NOT GLAND PRESSURE FORMS THE SEAL

UNLIKE ORDINARY ROD and plunger packings, J-M Sea Rings have tapered lips that seal on the work stroke, release on the return. Not depending on gland pressure for their leakproof seal, they last longer, reduce friction on rod or plunger.

A custom-made packing, Sea Rings are molded of the correct compositions for steam, hot or cold water, brine, vegetable and mineral oils, air and many other fluids and gases.

Ask your Supply House about Sea Rings and the complete line of J-M Packings and Gaskets. Or write Johns-Manville, Box 290, New York 16, N.Y.

JM PRODUCTS

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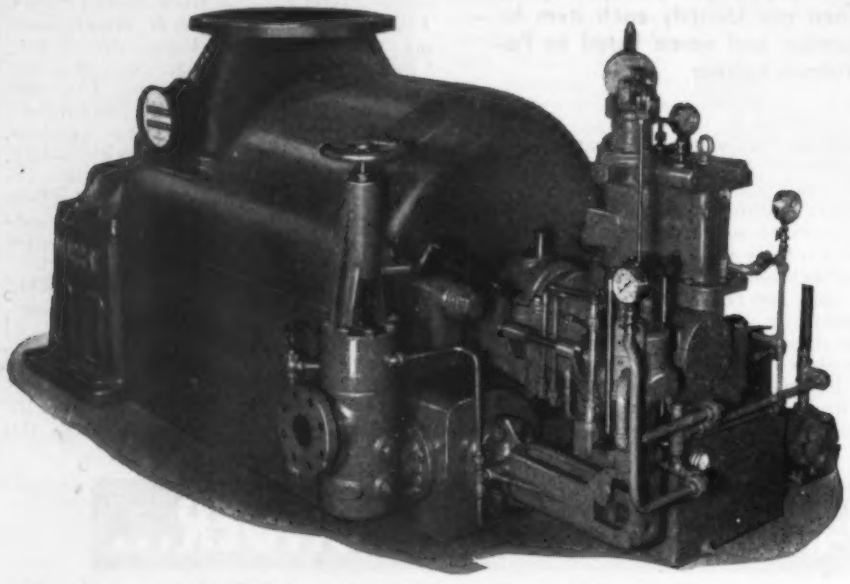


One of two MURRAY multistage steam turbines, designed to deliver 685 horsepower on steam at 110 pounds and exhausting to 26½ inches Hg vacuum, furnished to drive high speed centrifugal compressors for refrigeration in one of the most prominent Southern Hotels. A third unit has recently been shipped. Equipment includes variable speed oil relay governor, trip and throttle valve, strainer surrounding the double seated balanced governor valve, and force feed lubrication.

MURRAY MULTISTAGE STEAM TURBINES

★ ★ ★ ★

The complete MURRAY line of steam turbines includes all variations of mechanical drives, and turbine generator sets up to and including 3000 KW rating.

Sales Representatives for Murray products are located in all principal cities.

MURRAY IRON WORKS COMPANY

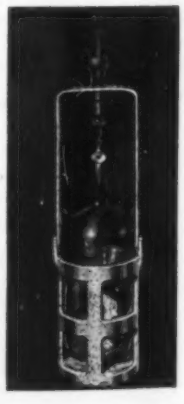
BURLINGTON, IOWA

Builders of Steam Power Equipment for Three Quarters of a Century

rating. All apparatus on the system back to the power source (including generators) is likewise subject to reduced stresses. The Valimitor Motor Starters are built to provide across-the-line starting, also in the reduced voltage starting style.

18—Sampling Bottle Cage

Vapor Recovery Systems Company, 2820 North Alameda Street, Compton, Calif., has announced this sampling cage which will hold a 32-ounce sampling bottle and can be used for obtaining spot or running samples through an opening of 4⅞ inches or larger. It was especially designed for use with a "Varec" gastight gauging and sampling unit on low-pressure vessels in lieu of a pressure type sampling bomb. The cage is merely lowered to the desired level and the bottle uncorked by slightly jerking on the tape or chain. It is absolutely safe, being made entirely of non-sparking materials.



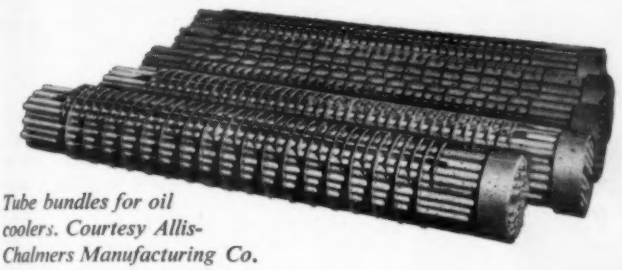
19—Collapsible Tap

Landis Machine Company, Waynesboro, Pa., has developed the improved style "LL receding chaser collapsible tap," designed primarily for tapping tapered threads. They are adjustable for thread length and can be used for American Tapered Pipe Threads or for any line pipe, tubing, casing, or drill pipe threads, listed in the API standards; providing, of course, that these threads are within the diametrical capacity of the taps. All operating parts are made of steel. Those parts subject to wear which may affect accuracy or efficiency are heat treated or hardened, and then precision ground. The taps offer an unusually rigid chaser support. The receding action of the chasers is accomplished through a fulcrumed lever principle. The collapsing action of the tap causes the

Importance of Protective Film

An important factor in the life of tubing handling various types of circulating water in petroleum refining, petro-chemical and chemical production is the protective film formed on the water side.

The corrosion rates of various metals and alloys are due largely to the character of the corrosion films formed and the speed with which they are re-established if damaged. Because the most highly protective films are often thin and invisible, their presence and importance is not generally recognized.



Tube bundles for oil coolers. Courtesy Allis-Chalmers Manufacturing Co.

Effect of Temperature and Water Composition — Temperature affects the reactions associated with film formation, and may affect water composition by increasing bacterial activity. Increased bacterial activity helps develop such gases as methane, ammonia, carbon dioxide and hydrogen sulphide in the water, which may injure some protective films and strengthen others. In some cases new tubing installed during the winter has given longer service than tubing installed during the summer because a more protective film has had an opportunity to form at the lower temperature.

Film formation varies with the type of water. Copper in Lake Erie water developed a thin, varnish-like protective film. On the other hand, copper exposed to water from certain wells and streams (in contact with calcium-rich mineral deposits) became covered with white to grayish-white or reddish-colored calcium carbonate scale, highly protective to copper.

Copper exposed to sea water develops a green-colored film bonded to a red-colored film attached to the copper. If the sea water contains a trace (0.5 or more parts per million) of hydrogen sulphide resulting from decomposition of organic matter, a marked increase in film thickness and in corrosion rate results. Copper galvanically coupled with a less noble metal such as iron, steel, aluminum, magnesium, zinc, etc., under certain conditions will form highly protective calcium-magnesium carbonate scales, often objectionable because of low heat transfer properties.

Preserving Protective Film—The protective film can be injured through abrasion from the sharp edges of sand, cinders, shells and other debris. Intake pipes should be kept clean and screens used to prevent the entrance of foreign matter. Tubes can be kept clean by rubber plugs, bristle brushes, high pressure water or air. Since scratches, dents and surfaces under porous deposits are among the points susceptible to attack it is desirable to maintain clean, smooth, undamaged metal surfaces. Chlorination and other procedures may be used to combat deposits of marine growth and slime.

Since the protective film may also be penetrated by impinging streams of water with or without air bubbles, turbulence should be reduced wherever possible and all connections checked to be sure that air is not entering the system.

Choosing the Correct Alloy — Alloy composition plays an important part in the formation of protective film. For example, the protective film formed on Aluminum Brass is repaired more readily than that formed on Admiralty. Tests conducted in various locations show how widely corrosion rates vary with the type of alloy, water composition and operating conditions. While no consistent rule can be laid down to correlate formation of protective film with corrosion rate, certain trends have been detected. For example, as the film thickness increases (in various waters) on Copper, Admiralty and Duronze IV (aluminum bronze), the trend is toward higher corrosion rates. When thin, protective films are present (less than 200 milligrams per square decimeter), low corrosion rates are encountered.

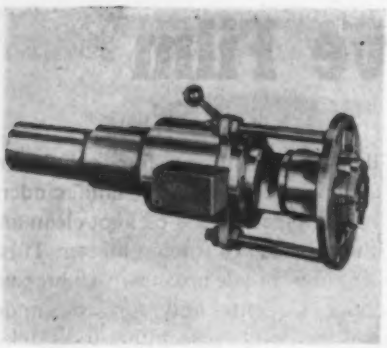
Since the average field or service corrosion test requires a period of from one to five years, it is advisable to anticipate tube requirements. Bridgeport's Corrosion Laboratory will be glad to co-operate with you in furnishing samples and conducting tests under actual operating conditions to aid in selection of the most suitable tubing alloy. Contact the nearest Bridgeport office.

The outstanding characteristics of the various condenser and heat exchanger tube alloys are described in Bridgeport's 120-page Condenser Tube Manual, which also contains suggestions for increasing tube life; corrosion data; methods of installing; specifications; etc. Write for your copy.

"Bridgeport" BRASS CO.

BRIDGEPORT BRASS COMPANY
BRIDGEPORT 2, CONN. • Established 1865
Mills at Bridgeport, Connecticut, and Indianapolis, Indiana
In Canada—Noranda Copper and Brass Limited, Montreal

CONDENSER AND HEAT EXCHANGER TUBING

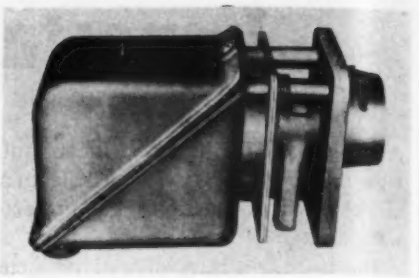


chasers to drop into the tap head, at the completion of the thread, thus freeing the chasers from the work and permitting the direct removal of the tap without reversing it or "backing out."

Positive identification of new equipment items by name and number listed in Petroleum Refiner insures prompt replies to your requests for literature and information.

20—Photoelectric Scanner

Combustion Control Corporation, 77 Broadway, Cambridge 42, Mass., has announced its photoelectric scanner Type 45PH5 for flame failure protection on oil burners. The equipment guarantees instantaneous burner shutdown in case of flame failure, thus providing a positive and immediate safeguard against this important and ever-present explosion hazard.



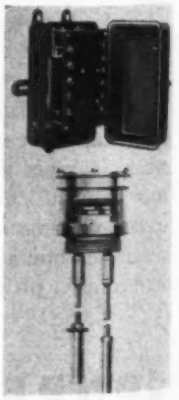
The scanner consists of phototube and vacuum tube amplifier housed in a compact, dust-tight aluminum case. It is mounted on the burner so that it has a clear view of the oil flame. Ask for Bulletin FF-1.

21—Lighting Fixture

An explosion-proof lighting fixture, designed specifically for use during manufacturing operations in the chemical, petroleum, and related industries, is announced by Safe Lighting, Inc., 90-16 Astoria Boulevard, Jackson Heights, L. I., N. Y. It is rated for use in Class 1, Groups A and B hazardous locations by the Underwriters' Laboratories, Inc., sponsored by the National Board of Fire Underwriters. The fixture, threaded for rigid conduit connection, is designed for operation with air pressure in the lamp compartment to prevent the entrance of surrounding hazardous atmospheres. It operates at an air pressure of about ten pounds, and should, for any reason, the pressure drop to a predetermined setting of about three pounds, the incandescent lamp automatically switches off. Two sizes are available, one using a lamp of 75 or 100 watts and the other a lamp of 150 or 200 watts.

22—Level Control

Photoswitch Incorporated, 77 Broadway, Cambridge 42, Mass., has announced a maintenance-free level control, Type 10CBI, a floatless device containing no vacuum tubes and operating with low voltage in the probe circuit. Stainless steel probe rods are installed in the tank with Photoswitch pressure-tight probe fittings. The liquid to be controlled makes or breaks contact with the probe and transmits to the control a minute electrical current at low voltage. This current controls a power circuit which operates a relay to actuate signals, valves, or pumps.



23—Potentiometers

Rubicon Company, 3653 Ridge Avenue, Philadelphia 32, has announced a new series of direct-reading temperature-calibrated portable potentiometers, ten standard catalog models calibrated over a wide range of temperature, for use with copper constantan, iron-constantan or chromel-alumel thermocouples. Special ranges can be supplied when re-

How to make your dollars go further in stainless piping

Practical engineers show you the dollar-saving way to increase your alloy piping efficiency in "Corrosion Resistant Piping," a comprehensive discussion prepared by the Taylor Forge engineering staff and on the presses now.

This new, fact-filled bulletin discusses the fundamentals involved in minimizing the cost of stainless materials . . . points out the advantages of conforming to IPS outside diameters . . . discusses Schedules 5S, 10S, 40S, and 80S in relation to pressures and temperatures . . . gives you a new slant on flanged connections . . . offers a realistic approach that will prove helpful to you. The supply is limited, so write today to reserve your copy.

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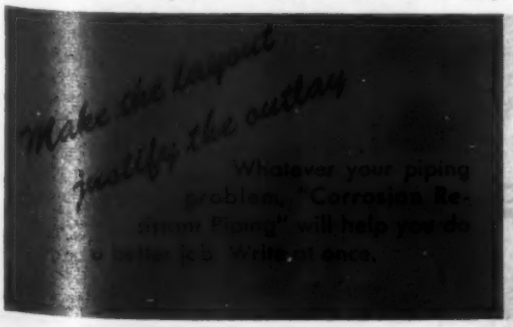

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3 SPECIFIC TYPES

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LUNKENHEIMER

150 LB. S.P. BRONZE GATE VALVES

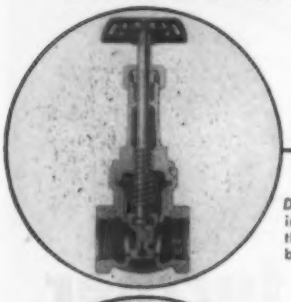


FIG. 2150
Double Wedge Disc—Rising Stem. For use where the flexibility of the double disc is needed.

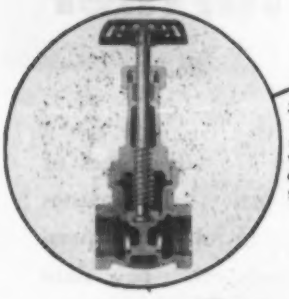
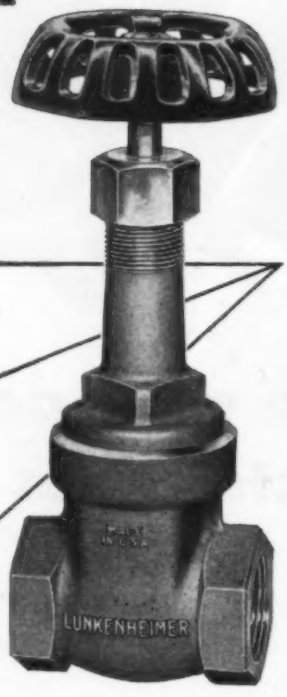


FIG. 2151
Solid Wedge Disc—Rising Stem. For use where the solid disc may be an advantage, as in food processing lines and handling gummy substances.



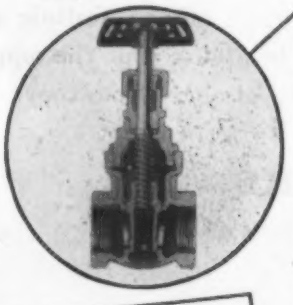


FIG. 2153
Single Wedge Disc—Non-Rising Stem. For installations where headroom is too restricted for rising stem valves.

• These new rugged designs meet all requirements for service where 150 lb. S.P. Bronze Gate Valves are used. They are engineered to provide a wide degree of interchangeability, making it possible to convert from one type to another by a simple interchange of trimmings. This means fewer valves and parts to stock, thus reducing maintenance expenses.

All three of these designs are equipped with Lunkenheimer patented wear-resistant alloy stem material which eliminates failures due to stem-thread wear.

Why not investigate the profit possibilities of these new valves in your plant—now.

PHONE YOUR DISTRIBUTOR FOR FOLDER

Design, construction and interchangeability are fully illustrated and described in Circular No. 574. Ask your distributor for a copy or write us direct.

ESTABLISHED 1862

THE LUNKENHEIMER CO.

"QUALITY"

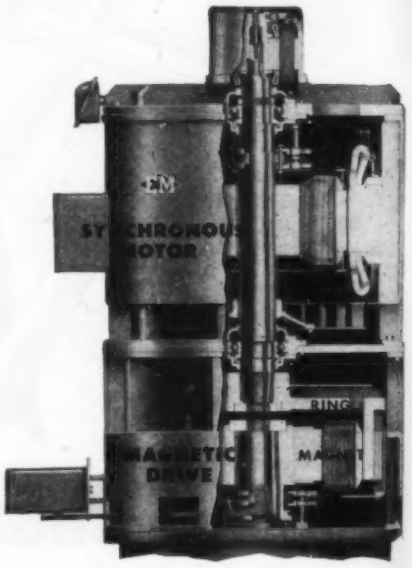
CINCINNATI 14, OHIO. U. S. A.

NEW YORK 13 CHICAGO 6
BOSTON 10 PHILADELPHIA 34

EXPORT DEPT. 318-322 HUDSON ST., NEW YORK 13, N. Y.

quired. Calibration may be had in either Centigrade or Fahrenheit degrees. Four models are listed with Rubicon high-sensitivity multiple-reflection "Pointerlite" galvanometers affording substantial improvement in sensitivity over that previously available on low temperature ranges. Accuracy in keeping with the high sensitivity is assured by special structural features which maintain the thermocouple reference-junction and the automatic reference-junction compensator at substantially equal temperatures, irrespective of changes in the ambient temperature.

24—Vertical Drive Unit



Electric Machinery Manufacturing Company's (Minneapolis 13, Minn.), "Vertical Synchronous Motor Magnetic Drive Unit" is designed to give smooth adjustable speed control for centrifugal pumps. Motor drives the ring of the magnet drive at constant speed and magnet member of magnet drive mounted on gear shaft operates the pump at speed required by liquid level control. Unit "offers smooth, wide-range speed control, precludes hunting and eliminates frequent motor starts and stops."

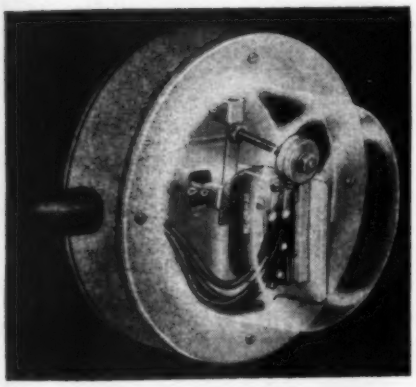
25—Packings

An improvement in packing valves, centrifugal and rotary shafts, reciprocating rods and other points with Teflon, is announced by Crane Packing Company, 1800 Cuyler Avenue, Chicago 13, these to be listed as the "Chemlon" line. "Teflon," E. I. duPont's chemically resistant flexible plastic, unique for its inertness, and not affected by any solvent acid mixtures, or acids, or caustic solutions at temperatures to 690° F., is being used in these packings. It is "the most efficient sealing protection against the escape of liquids, fumes or gases of a

For free copies of manufacturers' literature or more information about new equipment featured in Petroleum Refiner, simply identify the product by name and number.

highly inflammable or corrosive nature." Round cross-section braided spool-form packings are available in sizes ⅛ to 1-inch on spools. Braided material also is furnished. Rings of Teflon, (not merely machined bushings) "possess the required packing resilience."

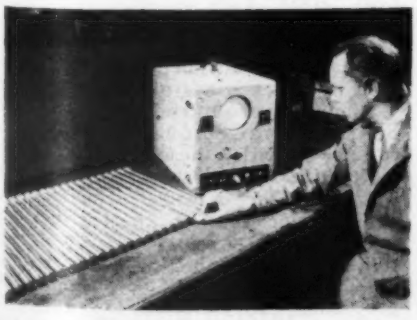
26—Small "Bin-Dicator"



The Bin-Dicator Company, 14615 East Jefferson Avenue, Detroit 15, announces a new, smaller "Bin-Dicator," the "Bantam," for use on very small hoppers, spouts, chutes, and conveyors, and other applications where it is not possible to use the standard size. The Bantam is only 5¾ inches over-all in diameter.

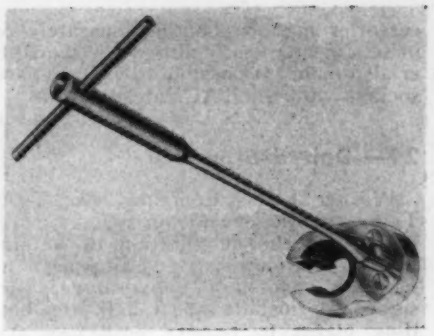
Both standard and Bantam are diaphragm-operated switches in sealed housings which mount on the outside of bins, hoppers, screw conveyors, etc., and signal changes in material levels. They will automatically start and stop filling and emptying equipment as the level of material reaches designated limits. Ask for Catalog G-730.

27—Supersonic Reflectoscope



Production of a new supersonic reflectoscope, Type SRO5, has been announced by Sperry Products, Inc., 1505 Willow Avenue, Hoboken, N. J. Used for non-destructive testing of metals and other materials for internal defects, and for testing welds, the specifications of the new instrument match those of the model presently in wide use, but radical changes have been made in size, appearance and operation. Sensitivity remains the same, but operation has been simplified by reducing the number of external controls to five. With these controls the operator varies sensitivity, pulse width, sweep length, screen markers, and frequency.

28—Open-End Wrench



C. J. Hendry Company, 27 Main Street, San Francisco, announces the new TAC open-end ratchet wrench for use on pipe, tube, conduit, cable, and rod fittings where an ordinary ratchet cannot be used. The ratchet heads operate in a 7½° arc or less, which makes it ideal for restricted areas.

TAC ratchet heads, sockets, and ac-

OILCO

SELF CLOSING
LOADING
LINE VALVES

MODELS
150
AND 150-S

The last word in valve design!

The result of years of study, experimenting, and testing, plus earnest co-operation with engineers of the major oil companies. Oilco Self Closing Line Valves are as close to perfection in design and efficiency as the industry has ever known.

Cast of tested all-bronze and equipped with phosphor bronze springs. Special disc will withstand temperatures up to 300 degrees oil heat. Construction permits quick opening and shockless closing of valve. Regulates any pressure up to 125 P. S. I. while line is under pressure. The advanced engineering of these valves eliminates wasteful leaks and costly equipment repairs. Model 150 is the hold-open type; 150-S is the stay-open type. Sizes: 2", 2½", 3", and 4".

For additional details see Oilco Catalog No. 500—Write for your copy today

OIL EQUIPMENT MFG. CO., INC.
3100 VERMONT AVE., LOUISVILLE, KY.
Canada: Empire Brass Co., Ltd., London, Ont.

cessories may be bought separately or in sets in practically all sizes. An adapter also makes it possible to use standard sockets with the TAC ratchet head.

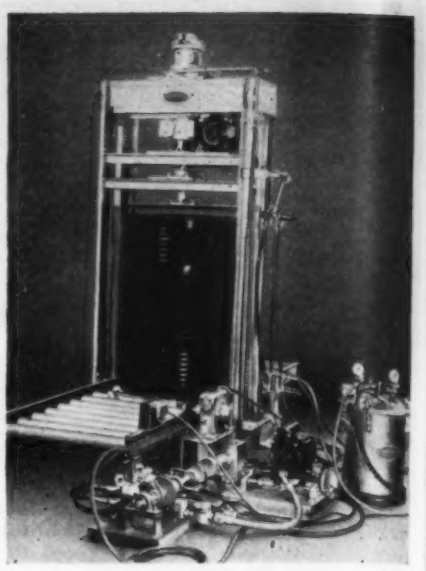
29—Dehydrator

Warner Lewis Company, Box 3096, Tulsa, announces a new two-stage dehydrator for the dehydration of butane, propane, gasoline, gas and air lines. The Excel-So two-stage dehydrator is designed for installation at bulk and bottling plants to remove both free and dissolved water from these products. The dehydrator chambers are designed for dessicant capacities of 2, 4, 6, 8, and 10 cubic feet so that standard factory-sealed bags of dessicant can be utilized.

Positive identification of new equipment items by name and number listed in Petroleum Refiner insures prompt replies to your requests for literature and information.

30—Automatic Chime Painter

Eclipse Air Brush Company, 374-376 Park Avenue, Newark 7, N. J., has introduced an automatic spray painter for steel barrel chimes which incorporates two Eclipse "Gat" guns, mounted in position for painting the chimes or for



striping. The entire procedure is automatic; the positioning of the barrels, the spraying and the discharge of the finished job. The equipment works on the low-pressure principle requiring from one-third to one-half the pressure used by high pressure type equipment. Offspray thus is reduced.

31—Flow Meter

Fischer & Porter Company, Hatboro, Pa., has announced a new steam jacketed "Flowrator" (formerly rotameter) instrument designed for materials having high melting points such as molten sulphur, naphthalene and phosphorus. Remote totalization, recording and control of the flow rate is available. Flow indication is also provided at the primary element. The meter indicating extension is furnished with steam heating coils and the entire meter body is jacketed for 100 psi. steam gauge pressure to insure that the material metered remains in the liquid phase in all parts of the metering instrument.

32—Adjustable Coupling

An adjustable coupling for flange mounted magnetos is announced by Wico Electric Company, West Springfield, Mass. This advance in magneto design is valuable because of the many variations in magneto drive lug locations in relation to advance spark timing on tractors and engines of different makes.

There are two models of four cylinder S.A.E. flange mounted magnetos equipped with these adjustable lug plates: the XH2500 which rotates clockwise and the XH3000 which rotates counter clockwise. A knurled lock nut, with two set screws and a tool hole, tightens around the lug plate. On the lug plate are five marked positions, and providing five different lag angles at which the lugs can be set. Through this new adjustable lug plate, magneto replacements can be made on 68 different

Another Spray Pond
FREE FROM ALGAE AND SLIME

WITH A *Paddock* HIGH-CAPACITY CHLORINATOR

The spray pond for the power plant of a large Southwestern University is kept free of algae and slime through constant chlorination. A Paddock Chlorinator requires very little erection space for efficient operation . . . note the compactness of this rugged unit.

Be assured your cooling equipment operates at peak efficiency and vital machinery is protected by installing a PADDOCK Chlorinator. It is the positive, but inexpensive method of eliminating destructive algae and slime.

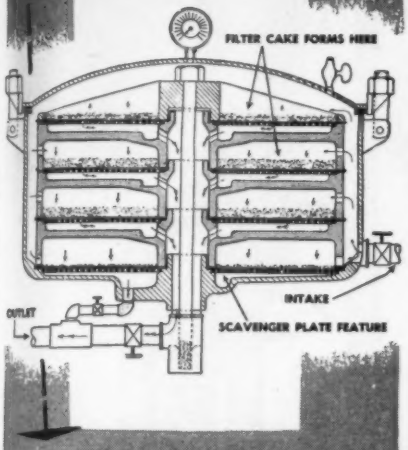
The Paddock Chlorinator operates on a high-vacuum principle with no moving parts to wear out. Capacities up to 1,000 lbs. of chlorine per 24 hours. Positive control.

Write today for further information as to how the PADDOCK Chlorinator can solve your chlorination problem.

Ask about SURECLOR to be used as a standby chlorinator

Paddock Engineering Co. of Texas
3727 ATWELL M&M BUILDING
DALLAS 9, TEXAS
HOUSTON 2, TEXAS

the *horizontal plate* principle



. . . makes these the "filters that filter all liquids"—

SPARKLER
Horizontal Plate
FILTERS

. . . and here's the story:

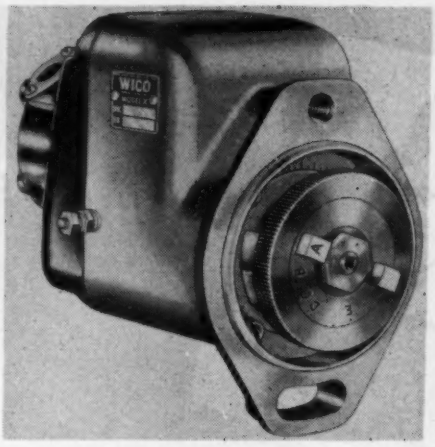
- Sparkler Horizontal Plate Filters handle any liquid from heavy varnishes to light alcohols, including products such as acids, oils, beverages, milk, pharmaceuticals, plating solutions, water, etc.
- Equally efficient performance on intermittent or continuous operation, under a wide range of temperature, pressure and viscosity conditions.
- Equally effective whether removing carbons and contact clays or clarifying and polishing with filter aids.
- Patented Scavenger Plate permits complete batch filtration. (It's virtually an auxiliary filter with an independent control valve.)
- Unexcelled filter cake stability—no slipping or breaking.

. . . why?

Because filter media are supported on a horizontal plane and filter aids floated into position uniformly, filtration takes place uniformly over entire filtering areas. Flow through filter is always *with* gravity.

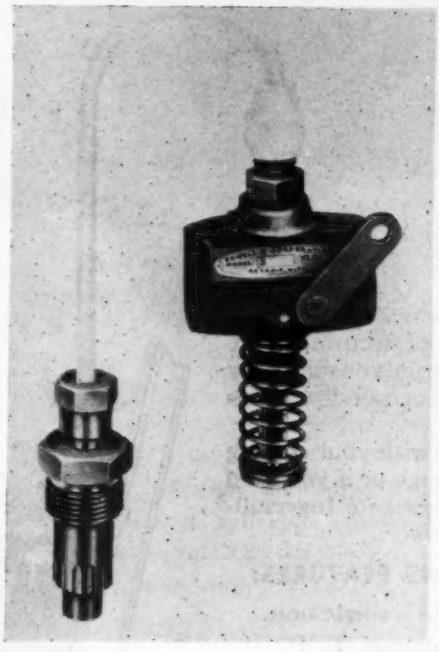
Sparkler Filtration Is *Engineered* Filtration—we invite correspondence on your problem. You will receive the advice of filtration scientists with a quarter of a century of experience in a specific field.

SPARKLER MANUFACTURING CO.
MUNDELEIN, ILLINOIS



models made by eleven different engine manufacturers with the two different magneto models.

33—Diesel Engine Pump



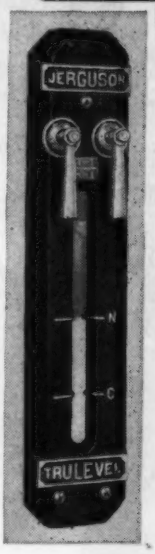
A new and simplified single-cylinder pump for diesel engines in the 5 to 15-horsepower range is announced by Ex-Cell-O Corporation, Detroit 32. The pump features an exceptionally simple design, and is to be used for one- and two-cylinder small high speed diesel engines. Designated as Model "S," it is available in a range of plunger diameters from ¼ to ⅜ inch. The combination of this new pump and the Ex-Cell-O nozzle "makes a reliable injection system for small engines," it was said.

34—Process Control Timer

C. J. Tagliabue Corporation (N. J.), 614 Frelinghuysen Avenue, Newark 5, N. J., has announced its TAG time-

When writing manufacturers' for additional information, you will speed reply by identifying the information by item number, name and page number of this issue of Petroleum Refiner.

Here's A Better Way To Read Water Levels Of Inaccessible Boiler Drums!



Use New

JERGUSON TRULEVEL GAGES

For All Distant Reading Problems

JERGUSON TRULEVEL Gages are the ideal solution to your problem when you need to read boiler water level accurately at a distant point, as in the case of inaccessible waste heat boilers.

TRULEVEL brings the liquid level reading of water, or of any condensing medium which you may be using, right down where you can see it. Complete accuracy of reading is assured by the use of a new type datum column, located at the drum.

Quick checking at the distant reading point is another important feature of TRULEVEL, and this is patented and exclusive with Jerguson. By simply turning the two valve handles on the cover it is possible to check gage accuracy *in a matter of seconds.* For accuracy and safety use the Jerguson TRULEVEL.

IMPORTANT! *Manometric fluid used in TRULEVEL Gage is color fast! Simple to maintain. No leakage. Another important feature of Jerguson TRULEVEL Gages.*

Write for Jerguson Trulevel Data Unit No. 38, without obligation, today!

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We actually mean water, for when hot summer days come along, the problem of securing large quantities of chilled water is a serious one in many industries . . . Especially if river or pond water is the main source of supply.

If you've been having trouble with your cooling water supply—if its not cold enough or if you need more of it—then you should investigate Ingersoll-Rand Water-Vapor Refrigeration.

HERE ARE A FEW IMPORTANT FEATURES:

20 to 1200 tons of refrigeration in a single unit.

Chilled water temperatures of approx. 45°F.

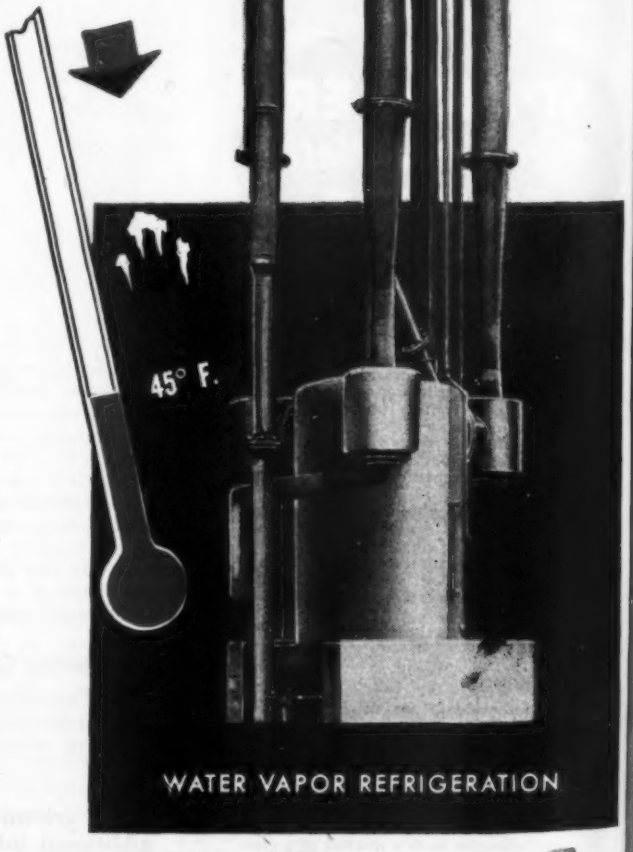
Water is the only refrigerant . . . there are no expensive, dangerous or toxic refrigerants to worry about.

There are no moving parts in the cooler itself. Cooling is obtained by direct evaporation of water in a high vacuum.

Units are entirely self supporting and can be installed out doors.

HERE'S HOW TO GET MORE INFORMATION:

First, ask the nearest Ingersoll-Rand Branch Office for a copy of bulletin No. 9143-A. If you would prefer to discuss your problem in detail, one of our engineers will be glad to call on you.



AIR TOOLS
COMPRESSORS
CONDENSERS
ROCK DRILLS
TURBO BLOWERS
CENTRIFUGAL PUMPS
OIL & GAS ENGINES

Ingersoll-Rand

11 BROADWAY, NEW YORK 4, N. Y. 28-13

schedule controller which "can be synchronized with any system of air-operated semi-automatic temperature and pressure control now in use to make the process fully automatic." Upon starting a signal light above the button flashes on. By means of an adjustable cam, timing begins immediately, or, if desired, when the temperature has reached the processing point. This temperature is maintained for the predetermined length of time. All valves—steam, air, drain, overflow and cooling water—are operated as required and all manual adjustments heretofore performed by the operator are eliminated. At the completion of the process and the cooling period, the signal light is extinguished.

35—Blowers

Bulletin 6A-4 by The Industrial Division, Bryant Heater Company, 1020 London Road, Cleveland 10, Ohio, covers a line of light weight, "Hi-Flo" centrifugal blowers in 4 to 18-ounce pressure range, 6000 to 48,000 cfh capacities. Diagrams, and capacity and dimensional tables for the complete series are included.

36—Electric Weld Goods

"Republic Electric Weld Oil Country Goods" a booklet issued by Republic Steel Corporation, Republic Building, Cleveland 1, Ohio, gives the highlights of the manufacture of Republic electric resistance weld pipe as the process affects the quality of the product. Advantages of the electric weld process for oil country line pipe, casing and tubing are cited. Ask for Form ADV 504.

37—Oil Burning System

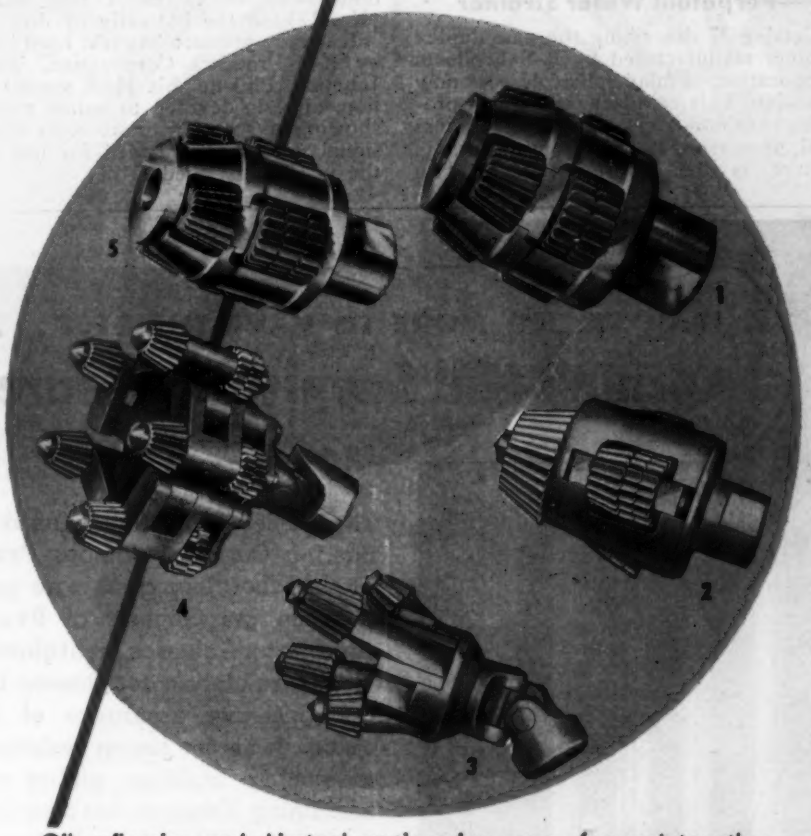
Schutte and Koerting Company 12th and Thompson Streets, Philadelphia 7, announce a new bulletin on mechanical fuel oil burners used for operating steam boilers in industrial and power plants. Burners are described and general information on their construction and operation is given as are data on dimensions, pressure capacities and weights of the various burners, forced and natural draft air control registers.

38—Water Conditioning

Wright Chemical Corporation, 627 West Lake Street, Chicago 6, manufacturing chemist specializing in the development, production, application and control of water condition chemicals, has issued a folder describing its products and services. Touched on are the company's analytical and research laboratories which are equipped with modern facilities and staffed with "chemists who are specialists in the causes and solutions for all types of problems common to aqueous systems." Field engineering service, available for consultation on water conditioning as well as regular laboratory service for periodic checks on conditions in clients' aqueous systems also are described.

Requests for manufacturers' literature get prompt replies when you identify each item by number and name listed in Petroleum Refiner.

THESE HEADS keep tubes at peak efficiency



Oil refineries and Airetool engineering move forward together. To keep oil refineries operating at peak efficiency, clean tubes are essential. AIRETOOL offers the right combination of motor and cutter, brush and drill head for maximum *results*.

Just a few of the many AIRETOOL cleaning heads are illustrated. There's an AIRETOOL head for tubes — bent or straight — ¼" to 24" I.D. For further information, write The Airetool Manufacturing Company, 316 S. Center St., Springfield, O.

1. SINGLE EXPANSION HEAD
for straight tubes 1½" to 4¾" I.D.

2. DOUBLE EXPANSION HEAD
with front offset cone cutter for straight tubes 3" to 10" I.D.

3. FORWARDLY SWING ARM HEAD
for all bent tubes 1¾" to 12" I.D.

4. WING ARM HEAD
for straight lines 6" to 24" I.D.

5. SINGLE EXPANSION HEAD
with 3 tiers of cutters; same head also available with 4 tiers.

THERE'S AN AIRETOOL TUBE CLEANER AND EXPANDER FOR EVERY TYPE OF TUBULAR CONSTRUCTION

Branch Offices: New York, Philadelphia, Chicago, Houston, Baton Rouge. Representatives in principal cities.

39—Tube Expanders

Gustav Wiedeke Company, Small Tools Department, Dayton 1, Ohio, has issued New Ideal Bulletin 61, describing adjustable tube expanders developed especially for rolling small tubes in thin, thick and multiple tube sheets of condensers, coolers, heat exchangers and similar units.

40—Perpetual Water Strainer

Catalog 37 describing the new duplex strainer manufactured by R-S Products Corporation, Philadelphia 44, is now available. This compact mechanism provides continuous clean water for industrial, processing and utility purposes. Its feature is the incorporation of two basket strainer units within the main casing, arranged so that either can be cleaned while the other is functioning. The booklet includes drawings which indicate part dimensions and semi-log graphs of pressure loss and flow rates.

41—Valves

Including several score photographs, and tables keyed to drawings showing dimensions of valves, a new catalog (No. 17) on the butterfly or disc type valves they produce has just been issued by R-S Products Corporation, Wayne Junction, Philadelphia 44. A special section, also, is devoted to prime movers, showing a score or more with dimensional data recommended for use with the valves described.

The same glass that is used in making Corning's famous PYREX brand laboratory glassware goes into the manufacture of PYREX brand gauge glasses, sight glasses, oil cup and lubricator glasses. It is your positive assurance of top quaity. It means longer resistance to etching, staining, pitting and scratching. It means that their cost, service considered, is lowest.

A LINE THAT ANSWERS ALL REQUIREMENTS

GAUGE GLASSES: PYREX and CORNING brand tubular gauge glasses and MACBETH brand flat gauge glasses provide good visibility over prolonged periods, even under severe conditions (pressures up to 2,000 p.s.i.).

SIGHT GLASSES. PYREX brand sight glasses are made especially for ovens, absorption columns, reaction kettles, furnaces, pressure vessels, stills, tanks (pressures up to 300 p.s.i.) where safe internal visibility is necessary.

OIL CUP AND LUBRICATOR GLASSES: PYREX and CORNING brand glassware give you visibility plus long life on all types of machine operations.

Corning products are available from your nearest Mill Supplier . . . Call him today. Stock up. Be prepared for any emergency!

CORNING means research in GLASS

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CORNING GLASS WORKS, CORNING, N.Y.

SALES OFFICES: NEW YORK, CHICAGO, SAN FRANCISCO

PYREX GAUGE GLASSES BRAND

42—Steam Trap

W. H. Nicholson and Co., 12 Oregon Street, Wilkes-Barre, Pa., announce publication of Bulletin 1047 describing Nicholson industrial steam traps. A full line of traps ranging from ¼ to 2-inch in size, and from vacuum service to pressures of 300 psi. are described. Temperature range is up to 500 degrees. The traps are available in bronze, cast iron, and cast steel.

43—Electrodes Data

Arcos Corporation, 1500 South 50th Street, Philadelphia 43, has available a complete technical data sheet on 11 analyses of alloy electrodes for use in fabrication welding and salvage of both high and low alloy castings. Both corrosion resisting and heat resisting alloys are included, together with ACI casting designations by type and recommended Arcos electrodes for use with each.

44—Digest

Visco Products Company, Inc., P. O. Box 234, Houston 1, Texas, is issuing "Visco Digest" on a quarterly basis. The digest contains abstracts of articles of theoretical and practical information regarding oil production and refining from the Visco library by way of trade journals. Items of news also are included in the digest.

45—Coolers, Condensers

Joseph A. Coy Company, Inc., 3515 Dawson Road, Tulsa, has published a bulletin containing descriptive material concerning the design, fabrication, and field application of the new Coynco Stratube atmospheric and submerged type of cooler and condensers. These coolers and condensers are available in both horizontal and vertical types and in a complete range of sizes for any duty.

46—High-Pressure Pumps

Data Sheet 62 issued by Aldrich Pump Company, Allentown, Pa., describes various types and sizes of high-pressure pumps designed for oil field and process plant service. Sections on the Aldrich-Groff "Powr-Savr" controllable capacity pumps, triplex, and quintuplex pumps and the most recent additions to the Aldrich line, the septuplex and nonuplex pumps are included.

Data Sheet 67 contains details on Aldrich inverted multuplex pumps including the Aldrich triplex, quintuplex, septuplex and nonuplex.

47—Stainless Steel Piping

A new booklet, "Stainless Steel Piping —Why and Where to Use It," written by J. D. Mattimore, chief engineer of the product and research division of Tube Turns, Inc., 224 East Broadway, Louisville 1, Ky., includes: Reasons for using stainless steel piping; types of stainless steels, with a detailed description of types 304, 347, and 316; standardization of pipe and fittings; selection of pipe joints and fabrication by welding, etc.

48—Geared Motors

The use of geared motor power in driving machinery and the presentation of latest electrical motor models are

Requests for manufacturers' literature get prompt replies when you identify each item by number and name listed in Petroleum Refiner.

shown in a bulletin issued by U. S. Electrical Motors, Inc., 200 East Slauson Avenue, Los Angeles 54.

Comparative drawings showing common construction in contrast to the new design features of U. S. Syncrogear motors offer a new conception of motors for geared application. The advantage of using a pyramidal base to prevent internal and external stresses are illustrated.

49—Lubricated Plug Valves

American Car and Foundry Company, Valve Department, 30 Church Street, New York, has issued Catalog 3-C which describes the features of its lubricated plug valves. These valves are available in standard types and sizes, in steel, semi-steel, bronze, and other alloyed metals to meet special requirements.

50—Centrifugal Pumps

De Laval Steam Turbine Company, Trenton 2, N. J., has listed its single-stage pumps in a single catalog (No. 83-29) which presents features of De Laval design and construction, lists pump ratings and incorporates essential dimensions. With this catalog, engineers can select the required pump, estimate motor size and plan approximate installation dimensions.

51—Pressure Indicator

Several new ranges for the W&T "Absolute Pressure Indicator" are listed in Technical Publication 16A, which also illustrates the new "low capacity" case for the 6-inch dial model. Write Wallace & Tiernan Products, Inc., 1 Main Street, Belleville 9, N. J.

52—Fluid Meter Data

Bailey Meter Company, Cleveland, Ohio, has issued revised Bulletin 301-B, "Bailey Fluid Meters for Steam-Liquid-Gases," which is divided into ten different sections discussing, among other things, flow mechanisms, primary elements, integrators, auxiliary recorders, accessories, and installation features.

53—Welding Instruction

Air Reduction Sales Company, 60 E. 42nd Street, New York 17, has issued a folder which describes in detail its five available welding and cutting instruction books. Two volumes are devoted to arc welding, and two to oxy-acetylene welding and cutting. The fifth is "Manual of Design for Arc Welded Steel Structures," a 300-page "difinite work, the first of its kind ever published."

54—Stainless Steel

Publication of the fifth in its series of booklets on the new role of stainless steel in various industries, "Allegheny Metal in Chemical Processing," is an-

● The new HELICOID VACUUM GAGE gives the user several advantages at no extra cost.

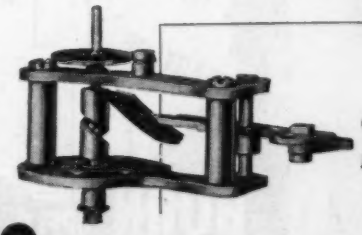
The pointer may be reset externally for changes in barometric pressure. This assures correct readings regardless of changes in room pressure.

The sub-divisions on the dial are in graduated steps of 0.2 inches. This makes the dial easy to read.

The dial graduations run counter-clockwise to denote negative pressure. This identifies the gage as a vacuum gage.

The special, phosphor bronze Bourdon tube has 300% greater torque. This assures more positive and precise response to slight changes in pressure, and results in accuracy to within 15/100ths of an inch.

HELICOID is first in new features — first in quality — first in durability — first in accuracy.



Only Helicoid Pressure Gages have the Helicoid Movement

ACCO

HELICOID GAGE DIVISION
AMERICAN CHAIN & CABLE
Bridgeport 2, Connecticut

nounced by Allegheny Ludlum Steel Corporation, 2020 Oliver Bldg., Pittsburgh 22. Each chapter is illustrated and there are charts showing physical, fabrication and other data on the various recommended grades of stainless steel along with other information valuable to the engineer. It is designed for both technical people and laymen.

55—Bronze Gate Valves

Circular 534, presenting a new line of "Union Bonnet" bronze gate valves, 200-pounds steam pressure, 400 pounds water-oil-gas, is available from The Lunkenheimer Company, Cincinnati 14, Ohio. Shown is the advanced design of these new valves, characterized by "the first application of full cylindrical body sections to bronze gate valves." The complete line is featured in union and bolted bonnet styles, with screw and flange ends.

56—Packing

United States Rubber Company, 1230 Avenue of the Americas, New York 20, has published a new chart for refineries and gasoline plants listing types of packing for use in connection with acid, ammonia, brine, caustic, oil distillates, hot oil, propane and butane, hot water and cold water.

57—"Men and Materials"

Western Supply Company, Box 1888, Tulsa 1, has published a booklet describing shop equipment installed to provide a fully integrated heat exchanger plant, tooled and equipped for precision work. Western, in business for 41 years, recently has built supply stocks around the pipe, valve and fittings requirements of modern gasoline plants, refineries and chemical plants. The booklet also contains shell side heat transfer coefficients in the section devoted to engineering.

58—Templates

Rapidesign, Inc., Box 592, Glendale, Calif., has issued a new catalog covering the company's templates for engineers, designers, draftsmen and architects.

SH-H-H! OIL MAN SLEEPING!

Let him sleep . . .

Blaw-Knox Fog Nozzles protect his plant from fire. Non-clogging and instantly available, they are fire's worst enemies.

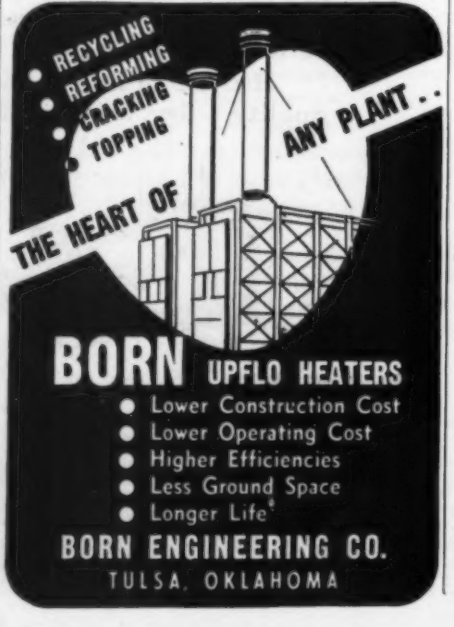
This highly perfected spray head is especially well fitted for refinery and tank farm installations. It delivers a "fog-plus spray"—a cloud of fine blanketing fog plus a driving spray that reaches the base of the fire, cooling and quenching.

Listed by Underwriters' Laboratories, Inc., and approved by Factory Mutual Laboratories.

Ask for Bulletin No. 2207

ALSO—
Blaw-Knox offers Standard Wet and Dry Pipe Systems, as well as Thermostatically Controlled and Supervised Deluge Systems.

BLAW-KNOX
SPRINKLER DIVISION
of Blaw-Knox Construction Company
829 Beaver Ave., N. S.,
Pittsburgh 12, Pa.
Offices in Principal Cities



BORN UPFLO HEATERS

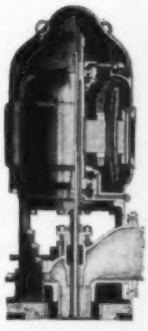
- Lower Construction Cost
- Lower Operating Cost
- Higher Efficiencies
- Less Ground Space
- Longer Life

BORN ENGINEERING CO.
TULSA, OKLAHOMA

PEERLESS HI-LIFT
REG. U. S. PAT. OFF.

FOR DOMESTIC
COMMERCIAL
INDUSTRIAL
MUNICIPAL
AGRICULTURAL SERVICE

The low cost pump for developing a maximum water supply from small diameter wells



FULLY PATENTED BY R. MOINEAU & PEERLESS PATS.

Here is one of the most simple and most positive of all deep well water pumping systems. In the Hi-Lift, Peerless utilizes an ingenious pumping element to literally squeeze water upward. Its pumping element consists simply of a hard chrome helically contoured rotor revolving in a similarly contoured rubber stator. That's all there is to this positive Peerless method of water lifting. It's the most forward step in pumping developed in the last 10 years.

fmc

CAPACITIES: 600 to 3300 Gallons per Hour from well depths to 600 feet.

PEERLESS PUMPS

Hi-Lift's pumping element is water lubricated, operates at half the usual pump speed; resists sand cutting abrasion and corrosion. When used with pressure tank, extremely high pressure may be developed without change or adjustment. These and many other Hi-Lift features are sure to make big savings in your water supply costs.

Peerless Bulletin B-142 fully describes and illustrates the many advantages of the Hi-Lift Pump. Write for copy today!

PEERLESS PUMP DIVISION
FOOD MACHINERY CORP.
LOS ANGELES 31, CALIF.; INDIANAPOLIS, IND.
District Offices: New York 5, 37 Wall Street; Chicago 40, 4554 No. Broadway; Atlanta Office: Rutland Bldg., Decatur, Ga.; Dallas 1, Texas; Fresno, Calif.; Los Angeles 31, Calif.

For handling corrosive crudes

National Alloy Steel Tubes give long, trouble-free service

"25 Analyses to choose from—"

- Low Carbon
- Low Carbon, ½ Moly.
- Low Carbon, ½ Cr., ½ Moly.
- Low Carbon, 1 Moly.
- 1¼ Cr., ½ Moly.
- 2 Cr., ½ Moly.
- 2 Cr., ½ Moly., 1¼ Sil.
- 2¼ Cr., 1 Moly
- 2½ Cr., ½ Moly., ¾ Sil.
- 3 Cr., ½ Moly., 1¼ Sil.
- 3 Cr., 1 Moly
- 5 Cr., ½ Moly.
- 5 Cr., ½ Moly., 1½ Sil.
- 5 Cr., ½ Moly., Titanium
- 5 Cr., ½ Moly., Columbium
- 7 Cr., ½ Moly.
- 8 Cr., 1 Moly.
- 9 Cr., 1 Moly.
- 12 Cr., Aluminum
- 17 Cr.
- 18-8
- 18-8 Titanium
- 18-8 Columbium
- 18-8 Molybdenum
- 25-20

FOR STILL TUBES · CONDENSER TUBES · HEAT EXCHANGER TUBES · REFINERY PIPING

THE problem of selecting refinery tubing to meet the wide variety of corrosive conditions and high temperatures is becoming more complicated than ever. Today, National Tube Company offers a selection of 25 different steel analyses to help you obtain the tubing that will give the best service at the lowest cost.

The next question is, "Which tubes are best for your conditions?" That's where our staff of tubing specialists can be of *real* help to you. They are working with corrosion problems every day. They know which steels should be used for sour crude oils containing large amounts of sulphur and which steels can be safely used at extremely high temperatures. The chances are that your problem may already have been solved for somebody else.

With 25 different analyses to choose from, practically every condition of corrosion or oxidation can be met with NATIONAL Seamless Steel Tubes. The alloys quickly pay for themselves through longer tube life and by keeping the plant on stream for greater periods.

To help improve your operations . . . to help reduce your costs and obtain greater safety and reliability, NATIONAL's staff of Tubing Specialists is ready to work with your engineers.

NATIONAL TUBE COMPANY
PITTSBURGH, PA.
Tubing Specialties Division
Columbia Steel Company, San Francisco, *Pacific Coast Distributors*
United States Steel Export Company, New York

WALLS WITHOUT WELDS

UNITED STATES STEEL

About EQUIPMENT SERVICE SUPPLIERS

Ohio Steel Names Mollman

E. H. Mollman, industrial engineer and sales executive, has been appointed to the sales and service staff of the Return Bend Division of the Ohio Steel Foundry Company, Lima, Ohio, which has plants in Lima and Springfield.

Mollman

Mollman, for the past 20 years with a large Illinois firm in the capacities of chief engineer, sales representative, vice president and works manager, will be associated with the Ohio Steel's Springfield office.

The new sales executive will be visiting the firm's major territories in the United States and Canada.

Farley Is Industrial Head

I. K. Farley, long associated with the company, has been appointed industrial manager of the Houston branch, Brown division of Minneapolis-Honeywell Regulator Company. Expansion in the chemical and petroleum industries in the Southwest area brought about the staff change.

R. L. Mallory, branch manager for the Houston Honeywell branch will devote more of his time to the over-all industrial activities of both companies in the Southwest area.

Thomas C. Wilson Names Five Sales Representatives

Five new sales representatives covering West Texas, New Mexico and Arizone, Iowa and East Nebraska, South Carolina and West North Carolina, East Tennessee and the lower peninsula territory in Michigan, have been appointed by Thomas C. Wilson, Inc., 21-11 44th Avenue, Long Island City 1, N. Y.

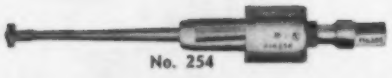
The new representatives include: Steel & Engineering Products, 311 Mills Building, El Paso, Texas; Interstate Machinery and Supply Company, 1006 Douglas Street, Omaha 8, Neb.; Plibrico Sales and Service Company, Box 1084, Charlotte, N. C.; Leinert Engineering Company, 412 East 5th Avenue, Knoxville, Tenn.; and Kiger Supply Company, 2842 West Grand Blvd., Detroit.

ADDITION TO PLANT COMPLETED

Paul Daniel, president of Daniel Orifice Fitting Company, announced last month that the new addition to its Los Angeles plant has been completed. New facilities will step up production of the Daniel line of orifice fittings, he said.

Wiedeke

TUBE EXPANDERS FOR DEPENDABLE . . . ECONOMICAL SERVICE



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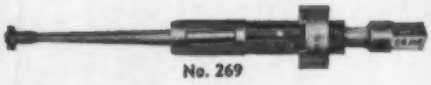
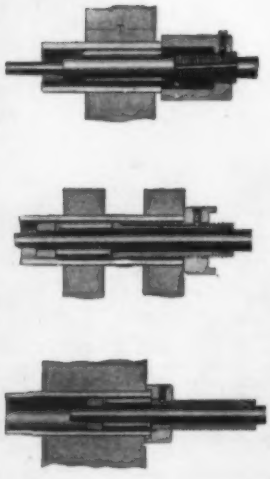


No. 269

WIEDEKE Adjustable Tube Expanders
Designed especially for rolling small tubes in Condensers, Heat Exchangers and similar units.
Style No. 254 is adaptable for rolling tubes to a depth of 2"
Style No. 269 is adaptable for rolling tubes in heavier or multiple tube sheets.
Leading users everywhere know there is a Wiedeke Tube Expander for every application.
For complete details, see your local dealer or write us today



The Gustav Wiedeke Company
DAYTON 1, OHIO

ESPECIALLY RECOMMENDED FOR USE IN THE

COPPER SWEETENING PROCESS

Nichols

TRIANGLE BRAND

COPPER SULPHATE

is preferred by leading refineries because of its high copper content, dependable uniformity and exceptional purity and freedom from foreign and inert matter.

99% + PURE

Quotations on request, on any quantity required. Shipments can be made from our nearest plant.

PHELPS DODGE REFINING CORP.
40 WALL STREET, NEW YORK
230 N. MICH. AVE., CHICAGO

New Engineering Company Opens in Houston Section

Process & Industrial Engineering Company, a newly formed organization, has recently entered the consulting and engineering field in Houston. The company is headed by four engineers of long experience: Roy E. Howard, Jr., mechanical engineering graduate of Rice Institute, is engineering manager; D. W. Edleman, who attended Chicago Technical College prior to entering the Merchant Marine during the war, has charge of the vessel and equipment design department; Charles M. Miller, who attended Texas A. & M. College prior to joining the armed services, is in charge of layout and piping work; and William J. Rice, chemical engineering graduate of Rensselaer Polytechnic Institute and a registered professional engineer in Texas, does the process and development work. The four were associated for several years while in the employ of Dow Chemical Company and more recently while with Wyatt C. Hedrick, engineer.

Howard

Edleman

Miller

Rice

PIECo, with offices at 2205 Bellaire Boulevard, is engaged in process and industrial engineering of varied nature. Facilities are also available for complete drafting room services.

Cooling Tower Consulting Specialist

Performance & Stress Analyses
STANLEY W. KRYSZEWSKI
Lic. Prof. Eng. N. Y.
14 Christopher St., Carteret, N. J.
Write for Particulars

RESULTS COUNT!

A gasoline stabilizer charge pump rod in Warren Petroleum Company's plant No. 20 at Fairbanks, Texas, was metallized in 1942.

SINCE THAT DATE, PACKING HAS BEEN REPLACED ONLY ONCE.
THE ROD IS IN EXCELLENT CONDITION.
NO SCORING — NO LEAKAGE.

Before metallizing, the rod scored which caused leakage and ultimate rod and packing replacement.

Write for complete information on how metallizing can reduce your maintenance costs.

GENERAL METALLIZING & MACHINE CO.
1409 Elysian St. Phone F-4738
Houston 10, Texas

QUICK TURBINE REPAIRS

If you need dependable Turbine repairs *in a hurry*, call us. We are completely equipped to repair and dynamically balance turbine rotors and any High Speed rotating elements in our modern shops.

25 Years Successful Experience

GULF ENGINEERING CO., INC.
"Service, Not Promises"
1502 INGEBORG ST. HOUSTON, TEXAS
916 S. PETERS STREET NEW ORLEANS, LA.

Hosford Named Koppers Chemical Division West Coast Manager

Charles F. Hosford, Jr., former president of Pennsylvania Coal Products Company, Petrolia, Pa., has been named West Coast manager for the Chemical Division of Koppers Company, Inc. Hosford will headquarter in San Francisco and will service Koppers' customers in California, Oregon, Washington, Arizona, Idaho, Nevada, and Utah.

Hosford joined Koppers early in 1947, after the Pennsylvania Coal Products Company was purchased by and became an integral part of the Koppers Chemical Division. He has been actively affiliated with the coal chemical industry since 1925.

Varec Appoints Klockner New Eastern Sales Manager

Lewis W. Klockner, Jr., has been named Eastern sales manager for Vapor Recovery Systems Company, Compton, Calif. Sales and engineering headquarters for this area remain at the same address, 30 Church Street, New York.

Klockner

Klockner, a graduate civil engineer of Lafayette College, previously has been associated with the sales engineering division of R. B. Carter Pump Company. During the war he served as captain in the Army engineers.

CONTROL

Scale and Corrosion in Water Cooled Equipment

WITH

Newly Perfected

Water Conditioning Chemicals

Recently developed applications of the newer colloids and surface-active agents in Wright Chemicals for the petroleum industry result in *improved* water conditioning—*positive* scale and corrosion control. Wright Chemicals contain 100% soluble, available chemicals—no waste or inert matter—insuring increased operating efficiency and reduced cost.

Cooling Towers . . .

Down time and replacement costs are materially reduced by effective scale and corrosion control with Wright Chemicals.

Compressors and Engine Jackets . . .

Heat transfer surfaces are kept free of scale and corrosion. Result? Greater efficiency.

Wright improved chemicals are the result of intensive study and research by men with years of experience in the development, production, application and control of water-conditioning problems.

Wright has no one cure-all to solve all problems. Each receives individual treatment. The Wright field engineer, who will call on you upon request, will obtain all necessary information and samples for examination in the modern Wright laboratory. Analyses are interpreted in view of supplemental information received, and recommendations made in the form of a proposal. Clients are provided with regular laboratory service as a periodic check upon conditions.

There is a Wright Field Engineer near you, anxious to help answer your scale and corrosion problems. No obligation.

Wright CHEMICALS

WRIGHT CHEMICAL CORPORATION
Specializing in Water Conditioning
GENERAL OFFICE AND LABORATORIES
615 West Lake Street Chicago 6, Ill.
Offices in Principal Cities

MULTI METAL

TAKES THE KINKS OUT OF WIRE CLOTH PROBLEMS

Multi-Metal is your standby for wire cloth of very type and description. We make wire cloth and filter cloth—and fabricate it into units. That has been our specialty for over a quarter of a century.

The unit shown here is an intake screen especially fabricated by Multi-Metal. It is coarse monel wire cloth that has been welded to a monel metal frame. Its purpose: to screen debris, keep solids out of pumps. It does the job to perfection. Write for illustrated catalog.

Wire Cloth by the Roll, Yard or Piece To the Completely Fabricated Job

More than 35 years of service to process industries

Multi-Metal
WIRE CLOTH COMPANY, INC.
1350 Garrison Ave., New York 59, N. Y.

. . . a valuable addition to the refiner's library

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The Ric-wiL Company Appoints Edwin Wert Vice President

The Ric-wiL Company of Cleveland has appointed Edwin A. Wert as vice president in charge of engineering. His services, the company said, "assures continued top research and scientific approach to solving piping problems in the complete range of pressure and temperature conditions."

Wert

Wert is known for his work on piping design and for his several published books on the subject. He is a member of the American Society of Mechanical Engineers and an alumnus of the University of California.

California Republic Supply Is Hammel-Dahl Representative

Hammel-Dahl Company, Providence, R. I., has announced appointment of The Republic Supply Company of Los Angeles as West Coast representative. The Republic Supply Company of California is an independently owned and operated company with main offices in Los Angeles and Emeryville and with 16 branch stores throughout the state. It specializes in equipment and material required in the refinery, chemical and allied industries. Republic's personnel includes John J. Pike, president; William T. Mayer and Andrew Fomilyant, sales engineers.

Pancake Given Promotion By ACF Special Division

Herman H. Pancake has been appointed manager of the American Car and Foundry Company's newly created Special Products Sales Division. Pancake succeeds H. D. Distelhurst, who, prior to his retirement, was manager of the miscellaneous sales division.

A native of Huntington, W. Va., Pancake started his ACF career in 1923. He became manager of mine car sales in 1945 and remained in that position until he assumed his present duties.

Worthington Retires With Forty-Year Service Record

J. T. Worthington, general field superintendent for the California Division of the Petroleum Rectifying Company of California, recently retired after more than 40 years of oil industry activity. Since his employment with Petreco, Worthington has supervised the installation of electric dehydrating plants from Texas to California. During recent years, his activities have been concentrated in California, in the Los Angeles Basin particularly.

Worthington

Worthington will continue to make Long Beach, Calif., his home.

Mixing Equipment In New Plant

Mixing Equipment Company has recently installed its entire manufacturing operation into a modern new plant, above, located in the outskirts of Rochester, N. Y. The plant is equipped with the last word in machine tools, jigs and inspection equipment, etc. Company officials believe the machine shop is "the most modern in existence." The plant is unique in that no old machine tools are being used. The former plant will be used exclusively for research and engineering. Edwin L. Lowthian has recently joined the firm as senior process engineer.

New Steel Firm in Houston

A newly organized firm, The McRan Company of Houston, has announced that it will handle Stran-Steel framing and Quonset buildings in South Texas. Franchisement of the firm by the Great Lakes Steel Corporation of Detroit, John F. McComb, president of the company, said, resulted from increasing demands for the nailable steel framing members and Quonset structures. Associated with McComb are Henry E. Randle, vice president; Adolph Stuermer, secretary, and W. F. Weed, treasurer.

Clark Names M. J. Galpin As London Representative

M. J. Galpin of London, England, has been appointed European representative for Clark Bros Company, Inc. of Olean, N. Y., and International Derrick & Equipment Company of Columbus, Ohio, and Dallas. Galpin spent several weeks in the United States recently, preparatory to assuming his duties abroad.

Galpin

Before joining the above two organizations, Galpin was with the Anglo-Iranian Oil Company for nine years and six years with the Roumanian oil industry. In the late war, Galpin served with the British Army as a lieutenant colonel. He is a graduate of Trinity College, Oxford University.

Beckman Instruments Now Factory-Serviced in Chicago

National Technical Laboratories, manufacturers of Beckman instruments, has established its own factory servicing headquarters at 9 South Clinton Street, Chicago, with George R. Kinkaid, Mid-Western representative, in charge.

The new Chicago service and repair department is staffed with factory trained specialists and features the latest equipment for servicing and repairing Beckman precision control instruments.

Petreco Man Returns to Army

Thomas V. Coleman, Jr., design engineer for Petroleum Rectifying Company, Long Beach, Calif., has recently been called back to active military duty. Coleman holds the rank of captain, and will return for service with the Signal Corps Headquarters at Ft. Monmouth, N. J.

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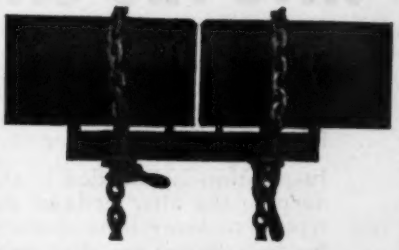
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Darby Succeeds Hilliard With Carnegie-Illinois Corporation

Election of J. Douglas Darby as vice president in charge of sales of Carnegie-Illinois Steel Corporation was announced last month. He succeeds Thomas J. Hilliard, with the company since 1936, whose resignation has been announced.

Darby

Darby was graduated from Yale University in 1919 and served as an officer in World War I. First employed as a slagman in the open hearth department of Alan Wood Steel Company, Darby became general superintendent and later assistant to vice president of sales. He joined the sales department of Carnegie-Illinois in 1939 and that year was made district manager of sales in Philadelphia. He came to Pittsburgh in 1945 as general manager of sales for the company.

New Region Established for Allis-Chalmers' Field Setup

Organization of a sixth region for the Allis-Chalmers general machinery division's field organization under William Arthur was announced last month. This Mid-Atlantic region, headquarters in Philadelphia, will embrace territory now covered by Philadelphia, Wilkes-Barre, Baltimore, York, Richmond and Charleston offices. The York and Charleston offices, managed by G. E. Conn and R. L. Halsted, respectively, formerly branch offices, thus become district offices.

Arthur is succeeded as Philadelphia district office manager, a post he held for 10 years, by Frank Freyler, manager of the Cincinnati district office since 1944. Freyler is succeeded by W. F. Daly, manager of the power section of the company's steam turbine department since 1943.

Kalstad Appointed

Kalstad Engineering & Sales Co., 38 Giralda Walk, Long Beach 3, Calif., have been appointed as sales representatives by Thomas C. Wilson, Inc., Long Island City, N. Y., manufacturers of tube cleaning equipment.

Lawrence Harper in Charge Of Franklin's Tulsa Office

Lawrence Harper, vice president of Franklin Supply Company, has assumed charge of the company's new office recently opened in Tulsa, according to an announcement by Jene Harper, president. The new office is located in Suite 425, Wright Building.

Harper

Lawrence Harper previously was sales manager in charge of the Michigan area. Elected director and vice president of Franklin Supply last April, he has been with the organization for the past 11 years, a service interrupted only by four years in the Army during World War II.